

Second Semester

Chemistry

(الكيمياء)

(Questions)



مركز القياس والتقويم التربوي
The Center for Educational Assessment
and Measurement (CEAM)



سَلْطَنَةُ عُمَانِ
وَزَارَةُ التَّحْقِيقِ وَالتَّجْوِيزِ

امتحان دبلوم التعليم العام للمدارس الخاصة (ثنائية اللغة)

للعام الدراسي ١٤٤٤ هـ - ٢٠٢٢ / ٢٠٢٣ م

الدور الأول - الفصل الدراسي الثاني

- زمن الإجابة: ثلاث ساعات.
- الإجابة في الورقة نفسها.

- تنبيه: المادة: الكيمياء.
- الأسئلة في (١٤) صفحة.

تعليمات مهمة:

- يجب على الممتحن التأكد من استلام دفتر امتحانه، مغلفاً بغلاف بلاستيكي شفاف وغير ممزق، وهو مسؤول عنه حتى يسلمه لمراقبي اللجنة بعد الانتهاء من الإجابة.
 - يجب الالتزام بضوابط إدارة امتحانات دبلوم التعليم العام وما في مستواه وأية مخالفة لهذه الضوابط تعرضك للتدابير والإجراءات والعقوبات المنصوص عليها بالقرار الوزاري رقم ٥٨٨ / ٢٠١٥.
 - يقوم المتقدم بالإجابة عن أسئلة الامتحان المقالية بقلم الحبر (الأزرق أو الأسود).
 - يقوم المتقدم بالإجابة عن أسئلة الاختيار من متعدد بتظليل الشكل (□) وفق النموذج الآتي:
س - عاصمة سلطنة عمان هي:
□ القاهرة □ الدوحة
■ مسقط □ أبوظبي
 - ملاحظة: يتم تظليل الشكل (■) باستخدام القلم الرصاص وعند الخطأ، امسح بعناية لإجراء التغيير.
 - يجب على الممتحن الامتثال لإجراءات التفطيش داخل المركز طوال أيام الامتحان.
- صحيح ■ غير صحيح □
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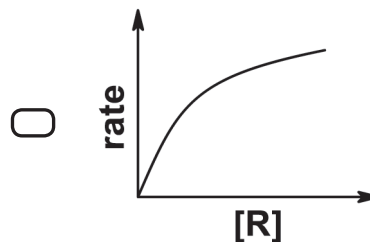
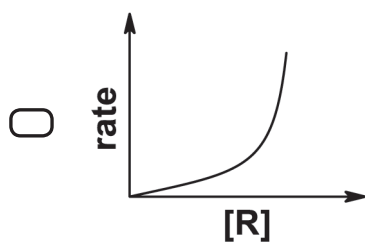
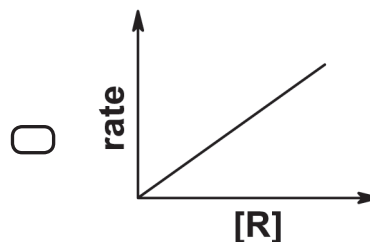
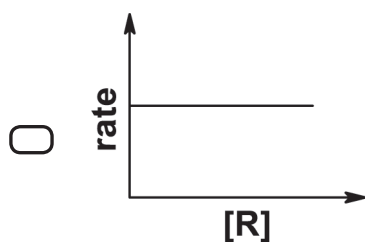
مُسَوِّدَةٌ، لَا يَتَمُّ تَصْحِيحُهَا

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Question 1 continued

6) Which of the following graphs represents the second order reaction?



7) Which of the following is correct in a neutral solution at 25 °C?

- pH is equal to $[\text{H}_3\text{O}^+][\text{OH}^-]$
- $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ are equal
- K_w value is $1.0 \times 10^{-7} \text{ mol}^2 \text{ dm}^{-6}$
- $[\text{OH}^-]$ value is $1.0 \times 10^{-14} \text{ mol dm}^{-3}$

8) A buffer solution is made from NH_4OH and NH_4Cl chloride.

What happens when a small amount of acid is added to this buffer?

- $\text{H}^+(\text{aq})$ in the acid combine with NH_4Cl
- $\text{NH}_4^+(\text{aq})$ ions dissociate to make more NH_3
- $\text{H}^+(\text{aq})$ in the acid combine with OH^- to make H_2O
- $\text{H}^+(\text{aq})$ in the acid prevent dissociation of the NH_4OH

Question 1 continued

- 11) Which of the following options correctly describes the oxidizing and the reducing agents in terms of electron transfer?

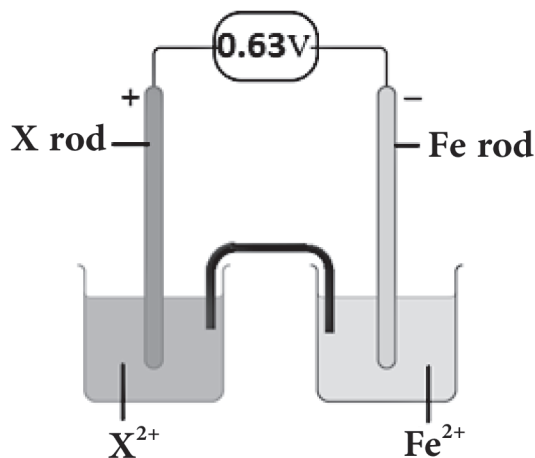
	Oxidizing agent	Reducing agent
<input type="radio"/>	gain electrons	lose electrons
<input type="radio"/>	gain electrons	gain electrons
<input type="radio"/>	lose electrons	lose electrons
<input type="radio"/>	lose electrons	gain electrons

- 12) What is the reducing agent in the following reaction?



- | | |
|---------------------------------------|-------------------------------------|
| <input type="radio"/> MnO_2 | <input type="radio"/> HCl |
| <input type="radio"/> MnCl_2 | <input type="radio"/> Cl_2 |

- 13) Which of the following options is correct for the voltage cell below?

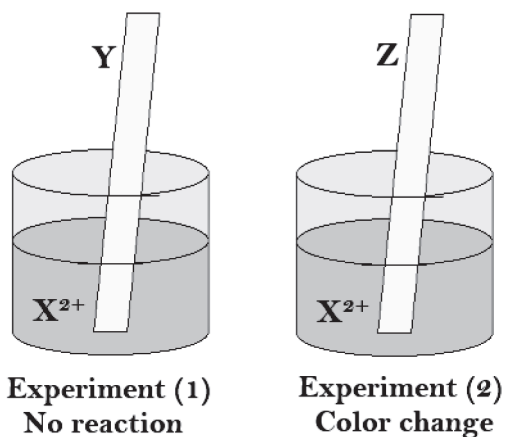


	Mass of X rod	Mass of Fe rod	E^θ for X^{2+}/X
<input type="radio"/>	increase	decrease	0.19
<input type="radio"/>	decrease	increase	0.19
<input type="radio"/>	increase	decrease	-0.19
<input type="radio"/>	decrease	increase	-0.19

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Question 1 continued

14) Two experiments were conducted with the following results:



Which of the following options is correct about the E^θ values for each metal ion / metal half-cell?

	$E^\theta = 0.40 \text{ V}$	$E^\theta = -0.81 \text{ V}$	$E^\theta = -2.41 \text{ V}$
<input type="radio"/>	Z^{2+}/Z	Y^{2+}/Y	X^{2+}/X
<input type="radio"/>	X^{2+}/X	Z^{2+}/Z	Y^{2+}/Y
<input type="radio"/>	Y^{2+}/Y	X^{2+}/X	Z^{2+}/Z
<input type="radio"/>	Z^{2+}/Z	X^{2+}/X	Y^{2+}/Y

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Question 2: Extended responses**(56 marks)**

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Write your answer for each of the following questions in the space provided.
Be sure to show all your work, including the correct units where applicable.

15) The compound $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$ is a complex containing both chloride ions and ammonia molecules as ligands.

a. Define the term complex ion.

b. Explain why a transition metal can form a complex ion.

c. What is the oxidation state of cobalt and the co-ordination number of the complex in this compound?

Oxidation state of cobalt _____

Co-ordination number of the complex _____

16) Study the following table, then answer the questions below:

A $[\text{Ni}(\text{CN})_4]^{2-}$	B $[\text{Pt}(\text{H}_2\text{O})_2\text{Cl}_2]$	C $[\text{Cu}(\text{en})_3]^{2+}$	D $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$
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a. Only write the "d" orbital electronic configuration of each the metal ions in the following complex ions:

Complex A: _____

Complex D: _____

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Question 2 continued

- b. Complex (B) has two geometric isomers (**cis** and **trans**). Draw the two isomers showing the three-dimensional shape of the bonds.

cis	trans

- c. For complex ion (C):

- (i) What is the type of ligand in complex ion (C)?

Monodentate Bidentate (shade the correct answer)

Explain your answer:

- (ii) How many pairs of electrons are donated by all the ligands in complex ion (C)?

- d. What color is complex ion (D)?

- e. When complex ion (D) reacts with 2 moles of hydroxide ions (OH^-) it forms a new complex (X).

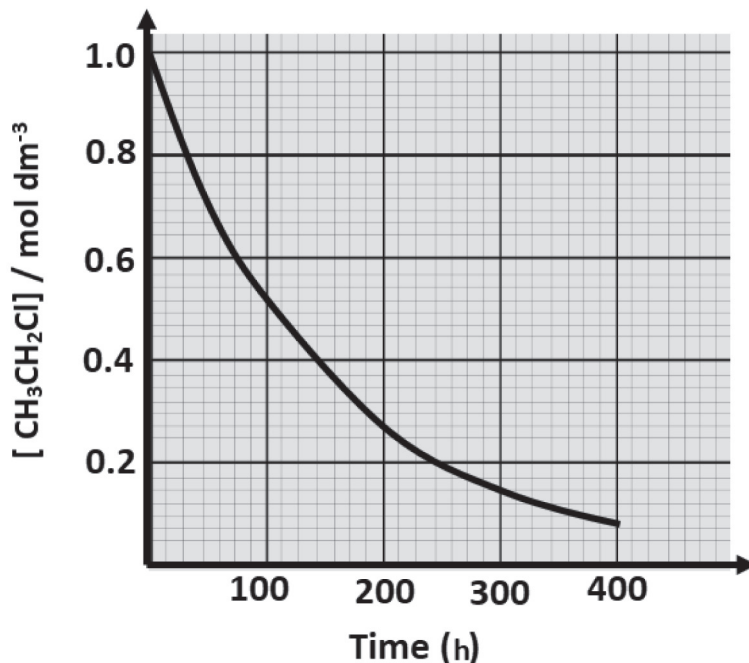
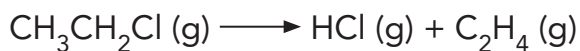
- (i) Write the equation for this reaction.

- (ii) What is the shape of the complex (X)?

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Question 2 continued

- 17) The graph below shows the change in concentration of ethyl chloride for the following reaction:



- a. What is meant by the term rate equation?

- b. What is meant by the term the half-life of the reaction?

- c. Using the graph above deduce the order of the reaction.

Zero order First order Second order

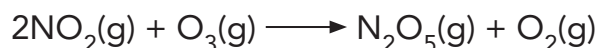
(Shade the correct answer)

Explanation _____

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Question 2 continued

- 18) Nitrogen dioxide reacts with ozone as shown below.



From the following experimental results obtained for the kinetics of the reaction between NO_2 and O_3 answer the following questions:

Experiment	$[\text{NO}_2(\text{g})]/\text{mol dm}^{-3}$	$[\text{O}_3(\text{g})]/\text{mol dm}^{-3}$	Initial rate/ $\text{mol dm}^{-3}\text{ s}^{-1}$
1	0.25	1.25	5.1×10^{-6}
2	0.50	0.625	5.4×10^{-6}
3	0.50	1.25	10.9×10^{-6}

- a. Deduce the order of reaction with respect to:

$[\text{NO}_2(\text{g})]$: _____

$[\text{O}_3(\text{g})]$: _____

- b. Write the rate equation for the reaction between $\text{NO}_2(\text{g})$ and $\text{O}_3(\text{g})$.

- c. Use the data in experiment 3 to calculate the value of the rate constant, k .

- d. With respect to $[\text{NO}_2(\text{g})]$, what is the change successive half-lives of this reaction?

- Constant
- Decrease with time
- Increase with time

(Shade the correct answer)

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Question 2 continued

- 19) The K_a values for some acids are listed below. Use them to answer the following questions.

Acid	K_a at 25 °C (mol dm ⁻³)
CH ₃ COOH	1.7×10^{-5}
HCOOH	1.6×10^{-4}
HCN	4.9×10^{-10}
HF	5.6×10^{-4}

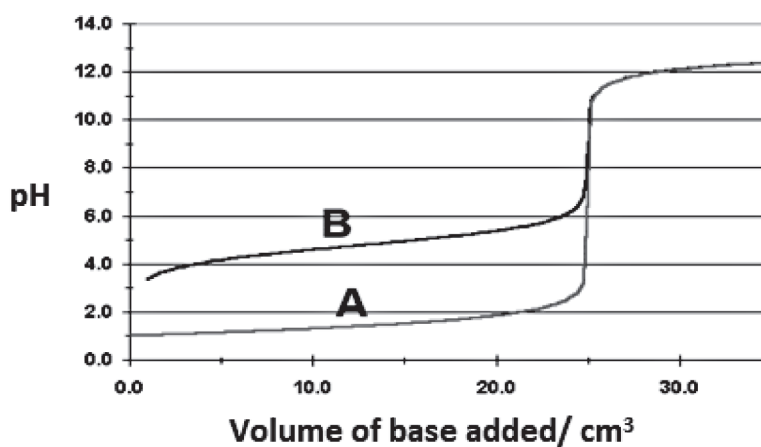
- a. Which one of the above acids has the highest value of pK_a ?

- b. For methanoic acid (HCOOH):

- (i) Write an expression for K_a for methanoic acid.

- (ii) Calculate the pH of a 0.08 mol dm⁻³ solutions of HCOOH acid.

- 20) The following graph shows the pH curve for the titration of different acids and bases. Study it to answer the questions below:



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Question 2 continued

- a. What type is each titration in terms of acid and base strength?
- Curve A: _____
- Curve B: _____
- b. What is the equivalence point for each titration?
- Curve A: _____
- Curve B: _____
- c. Why is phenolphthalein (8.2 - 10.0) a suitable indicator for the titration curve B?
- _____

- 21) The following table shows the pH change after adding a small amount of acid or base to solution (A) and (B). Study it to answer the questions below:

Solution	pH of solution	pH of solution	
		After adding acid	After adding base
A	5.00	2.00	12.00
B	5.00	4.98	5.02

- a. Which one is a buffer solution? Explain your answer.
- A B (Shade the correct answer)

Explanation: _____

- b. A buffer solution is prepared by adding 1.0 dm^3 of 0.20 mol dm^{-3} of a weak acid, HA, ($K_a = 1.6 \times 10^{-4} \text{ mol.dm}^{-3}$) to 1.0 dm^3 of 0.20 mol dm^{-3} sodium salt, NaA.

- (i) Define the term buffer solution.
- _____
- _____

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Question 2 continued

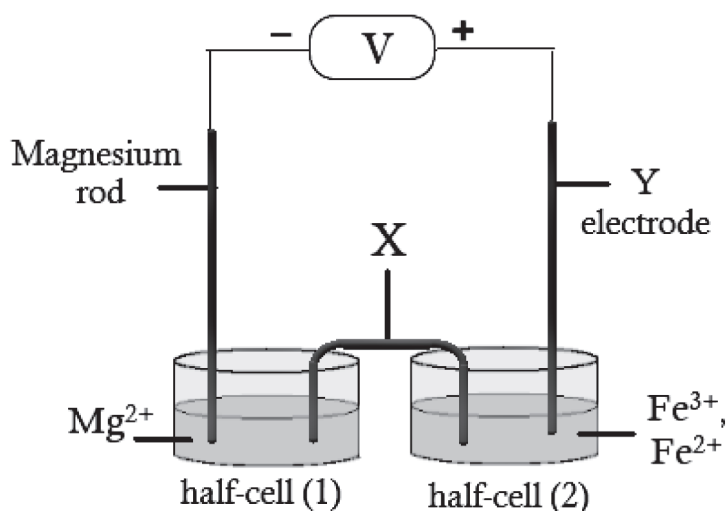
(ii) Calculate the pH of this buffer solution.

22) For the standard hydrogen electrode:

a. State the standard temperature and pressure.

b. Write the formula for the aqueous positive ions.

23) An electrochemical cell was set up under standard conditions as shown below:



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Question 2 continued

- a. What is the name of (X) shown in the figure above?

- b. Write the half-equation for the reaction that occurs in the half-cell (1).

- c. For the half-cell (2):

- (i) What is the substance made of (Y) electrode?

- (ii) What is the concentration of Fe^{3+} ?

- d. What is the direction of electron flow in this electrochemical cell?

- e. What would happen to the mass of magnesium electrode during the reactions that occur in this cell? Explain your answer.

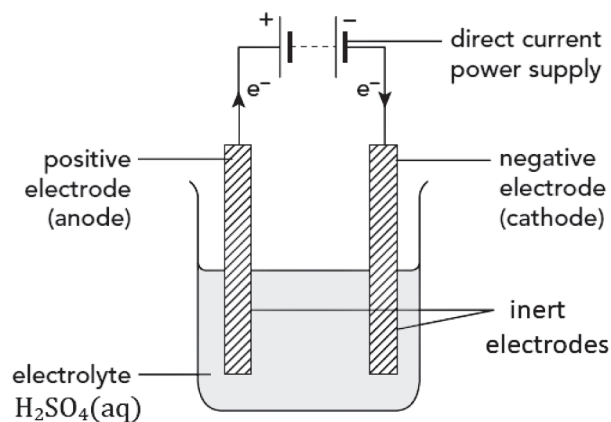
- f. Write the cell notation for this cell.

- g. Calculate the E^θ value for this cell.

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Question 2 continued

- 24) An aqueous solution of sulfuric acid was electrolyzed using inert electrodes as shown below:



- a. Identify the ions which will be oxidized and reduced in the anode and cathode, respectively:

In the anode: _____

In the cathode: _____

- b. What is the substance liberated during this electrolysis in:

The anode: _____

The cathode: _____

[End of Examination]

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PERIODIC TABLE OF THE ELEMENTS

1 H 1.008 Hydrogen	2 He 4.002602 Helium	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>Atomic Number → 1</p> <p>Symbol → H</p> <p>1.008 ← Atomic Mass</p> <p>Hydrogen ← Name</p> </div> </div>																																																																																																		
3 Li 6.94 Lithium	4 Be 9.0121831 Beryllium	5 B 10.81 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998403163 Fluorine	10 Ne 20.1797 Neon	11 Na 22.98976928 Sodium	12 Mg 24.305 Magnesium	13 Al 26.9815385 Aluminum	14 Si 28.085 Silicon	15 P 30.973761998 Phosphorus	16 S 32.06 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.948 Argon	19 K 39.0983 Potassium	20 Ca 40.078 Calcium	21 Sc 44.955908 Scandium	22 Ti 47.867 Titanium	23 V 50.9415 Vanadium	24 Cr 51.9961 Chromium	25 Mn 54.938044 Manganese	26 Fe 55.845 Iron	27 Co 58.933194 Cobalt	28 Ni 58.6934 Nickel	29 Cu 63.546 Copper	30 Zn 65.38 Zinc	31 Ga 69.723 Gallium	32 Ge 72.630 Germanium	33 As 74.921595 Arsenic	34 Se 78.971 Selenium	35 Br 79.904 Bromine	36 Kr 83.798 Krypton	37 Rb 85.4678 Rubidium	38 Sr 87.62 Strontium	39 Y 88.90584 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.90637 Niobium	42 Mo 95.95 Molybdenum	43 Tc 98 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.90550 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.8682 Silver	48 Cd 112.414 Cadmium	49 In 114.818 Indium	50 Sn 118.710 Tin	51 Sb 121.760 Antimony	52 Te 127.60 Tellurium	53 I 126.90447 Iodine	54 Xe 131.293 Xenon	55 Cs 132.90545196 Caesium	56 Ba 137.327 Barium	57 La 138.90547 Lanthanum	58 Ce 140.116 Cerium	59 Pr 140.90766 Praseodymium	60 Nd 144.242 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92535 Terbium	66 Dy 162.500 Dysprosium	67 Ho 164.93033 Holmium	68 Er 167.259 Erbium	69 Tm 168.93422 Thulium	70 Yb 173.054 Ytterbium	71 Lu 174.9668 Lutetium	72 Hf 178.49 Hafnium	73 Ta 180.94788 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.217 Iridium	78 Pt 195.084 Platinum	79 Au 196.966569 Gold	80 Hg 200.592 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98040 Bismuth	84 Po 209 Polonium	85 At 210 Astatine	86 Rn 222 Radon	87 Fr 223 Francium	88 Ra 226 Radium	89 Ac 227 Actinium	90 Th 232.0377 Thorium	91 Pa 231.03588 Protactinium	92 U 238.02891 Uranium	93 Np 237 Neptunium	94 Pu 244 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 266 Lawrencium

57 La 138.90547 Lanthanum	58 Ce 140.116 Cerium	59 Pr 140.90766 Praseodymium	60 Nd 144.242 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92535 Terbium	66 Dy 162.500 Dysprosium	67 Ho 164.93033 Holmium	68 Er 167.259 Erbium	69 Tm 168.93422 Thulium	70 Yb 173.054 Ytterbium	71 Lu 174.9668 Lutetium
89 Ac 227 Actinium	90 Th 232.0377 Thorium	91 Pa 231.03588 Protactinium	92 U 238.02891 Uranium	93 Np 237 Neptunium	94 Pu 244 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 266 Lawrencium

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Electrode reaction	E^{\ominus} / V
$F_2 + 2e^- \rightleftharpoons 2F^-$	+2.87
$S_2O_8^{2-} + 2e^- \rightleftharpoons 2SO_4^{2-}$	+2.01
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1.77
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.52
$PbO_2 + 4H^+ + 2e^- \rightleftharpoons Pb^{2+} + 2H_2O$	+1.47
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33
$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+1.23
$Br_2 + 2e^- \rightleftharpoons 2Br^-$	+1.07
$ClO^- + H_2O + 2e^- \rightleftharpoons Cl^- + 2OH^-$	+0.89
$NO_3^- + 10H^+ + 8e^- \rightleftharpoons NH_4^+ + 3H_2O$	+0.87
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$	+0.81
$Ag^+ + e^- \rightleftharpoons Ag$	+0.80
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77
$I_2 + 2e^- \rightleftharpoons 2I^-$	+0.54
$O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$	+0.40
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2 + 2H_2O$	+0.17
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+0.15
$S_4O_6^{2-} + 2e^- \rightleftharpoons 2S_2O_3^{2-}$	+0.09
$2H^+ + 2e^- \rightleftharpoons H_2$	0.00
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	-0.13
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	-0.14
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	-0.44
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	-0.76
$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$	-0.83
$V^{2+} + 2e^- \rightleftharpoons V$	-1.20
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	-2.38
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	-2.87
$K^+ + e^- \rightleftharpoons K$	-2.92

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سَلْطَنَةُ عُمَانِ
وَزَارَةُ التَّحْقِيقِ وَالتَّجْوِيزِ

امتحان دبلوم التعليم العام للمدارس الخاصة (ثنائية اللغة)

للعام الدراسي ١٤٤٤ هـ - ٢٠٢٢ / ٢٠٢٣ م

الدور الثاني - الفصل الدراسي الثاني

- زمن الإجابة: ثلاث ساعات.
- الإجابة في الورقة نفسها.

- تنبيه: المادة: الكيمياء.
- الأسئلة في (١٢) صفحة.

تعليمات مهمة:

- يجب على الممتحن التأكد من استلام دفتر امتحانه، مغلفاً بغلاف بلاستيكي شفاف وغير ممزق، وهو مسؤول عنه حتى يسلمه لمراقبي اللجنة بعد الانتهاء من الإجابة.
- يجب الالتزام بضوابط إدارة امتحانات دبلوم التعليم العام وما في مستواه وأية مخالفة لهذه الضوابط تعرضك للتدابير والإجراءات والعقوبات المنصوص عليها بالقرار الوزاري رقم ٥٨٨ / ٢٠١٥.
- يقوم المتقدم بالإجابة عن أسئلة الامتحان المقالية بقلم الحبر (الأزرق أو الأسود).
- يقوم المتقدم بالإجابة عن أسئلة الاختيار من متعدد بتظليل الشكل (□) وفق النموذج الآتي:
س - عاصمة سلطنة عمان هي:
□ القاهرة □ الدوحة
■ مسقط □ أبوظبي
- ملاحظة: يتم تظليل الشكل (■) باستخدام القلم الرصاص وعند الخطأ، امسح بعناية لإجراء التغيير.
- يجب على الممتحن الامتثال لإجراءات التفطيش داخل المركز طوال أيام الامتحان.
- يجب إحضار أصل ما يثبت الهوية وإبرازها للعاملين بالامتحانات.
- يجب الالتزام بالزي (الدشداشة البيضاء والمصر أو الكمة للذكور) والزي المدرسي للطالبات، ويستثنى من ذلك الدارسون من غير العمانيين بشرط الالتزام بالذوق العام، ويمنع على جميع المتقدمين ارتداء النقاب داخل المركز وقاعات الامتحان.
- يحظر على الممتحنين اصطحاب الهواتف النقالة وأجهزة النداء الآلي وألات التصوير والحواسيب الشخصية والساعات الرقمية الذكية والآلات الحاسبة ذات الذاكرة التخزينية والمجلات والصحف والكتب الدراسية والدفاتر والمذكرات والحقائب اليدوية والآلات الحادة أو الأسلحة أياً كان نوعها وأي شيء له علاقة بالامتحان.
- يجب على الممتحن الامتثال لإجراءات التفطيش داخل المركز طوال أيام الامتحان.

صحيح ■ غير صحيح □



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Question 1: Multiple Choice Items**(14 marks)**

There are 14 multiple-choice items worth one mark each.

Shade in the bubble () next to the **correct** answer for each of the following items.

1) Which of the following ligands is a bidentate ligand?



2) What is the electron configuration of Fe ion in the complex $[\text{Fe}(\text{H}_2\text{O})_5\text{OH}]^{2+}$?



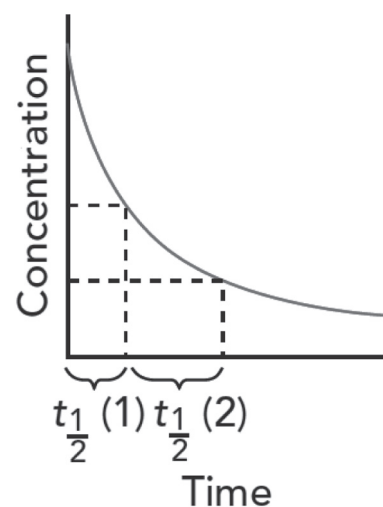
3) Which of the following options about the $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]^{2+}$ complex ion is correct?

	Geometrical Shapes	Oxidation state of chromium
<input type="radio"/>	tetrahedral	+3
<input type="radio"/>	octahedral	+2
<input type="radio"/>	tetrahedral	+2
<input type="radio"/>	octahedral	+3

4) The graph below shows the half-lives measured for a reaction.

Which of the following options about this reaction is correct for this graph?

	Reaction order	Half-life
<input type="radio"/>	first-order	independent of the initial concentration
<input type="radio"/>	second-order	independent of the initial concentration
<input type="radio"/>	first-order	dependent on the initial concentration
<input type="radio"/>	second-order	dependent on the initial concentration



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Question 1 continued

Use the following information to answer questions (5 and 6).

For the reaction below,



The rate law is $\text{rate} = k [\text{ClO}_2]^2 [\text{OH}^-]$

5) What is the reaction rate unit of this reaction?

$\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$

$\text{dm}^6 \text{mol}^{-2} \text{s}^{-1}$

$\text{mol dm}^{-3} \text{s}^{-1}$

$\text{mol}^{-1} \text{dm}^{-3} \text{s}^{-1}$

6) Which one of the following statements about this reaction is **correct**?

 The reaction is second order in overall. The reaction is second order with respect to OH^- . The half-life of this reaction is constant with respect to ClO_2 . If $[\text{ClO}_2]$ is doubled, the reaction rate will increase by a factor of 4.

7) What is the value of K_w at 25°C ?

1.0×10^{-4}

1.0×10^{-7}

1.0×10^{-12}

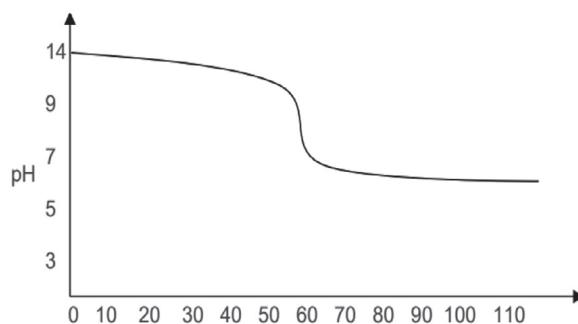
1.0×10^{-14}

8) If $[\text{H}^+]$ at an equivalence point is calculated to be $1.0 \times 10^{-5} \text{mol} \cdot \text{dm}^{-3}$ for a particular titration, which of the following acid-base indicators is more suitable for this titration?

	Indicator	pH range
<input type="checkbox"/>	Methyl orange	3.2 – 4.4
<input type="checkbox"/>	Methyl red	4.2 – 6.3
<input type="checkbox"/>	Phenol red	6.6 – 8.0
<input type="checkbox"/>	Phenolphthalein	8.2 – 10.0

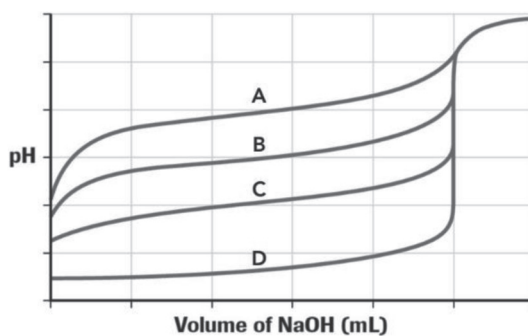
Question 1 continued

9) What type of titration is represented by the pH curve below?



- Strong acid-weak base Weak acid-strong base
 Strong acid-strong base Weak acid-weak base

10) The graph below shows four curves for the titrations of different acids with NaOH solution.



Which titration curve represents the titration of an acid with the highest K_a value?

- A B
 C D

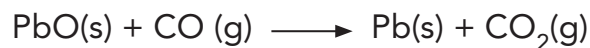
11) Which of the following occurs in a reduction reaction?

- gain protons loss protons
 gain electrons loss electrons

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Question 1 continued

12) For the reaction in this equation:



What is the oxidizing agent in this reaction?

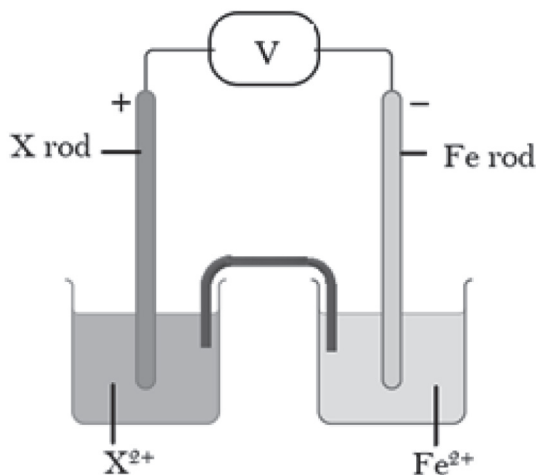
PbO

CO

Pb

CO₂

13) Which of the following options is correct for the voltage cell below?



	<i>X</i> electrode	E^\ominus cell (V)
<input type="radio"/>	Cu	0.10
<input type="radio"/>	Zn	0.32
<input type="radio"/>	Cu	0.78
<input type="radio"/>	Zn	1.20

14) Which of the following pairs in the reaction between them is not feasible?

Ag⁺, Mg

Cu²⁺, Mg

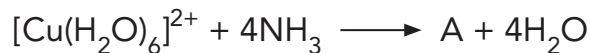
Zn²⁺, Cu

Ag⁺, Cu

Question 2: Extended responses**(56 marks)**

Write your answer for each of the following questions in the space provided.
Be sure to show all your work, including the correct units where applicable.

Study the following two reactions:



15) a. (i) Define transition elements.

(ii) Write the formula of the complex ion A.

(iii) Draw the shape of the complex ion A. Your drawing should clearly show a three-dimensional shape and include the overall charge on the complex ion.

b. Explain why copper is an exception in the general trend when filling electrons in the subshell.

c. (i) Write the formula of the complex ion B. _____

(ii) What is the shape of the complex ion B? _____

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Question 2 continued

16) When the complex ion $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ is treated with $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$ (en) ligand, the complex ion $[\text{Co}(\text{en})_3]^{2+}$ is formed.

a. Define the term ligand.

b. What is the oxidation state of cobalt and the co-ordination number of the complex ion formed?

Oxidation state _____

Co-ordination number _____

c. What type of ligand is formed in this complex ion?

d. How many pairs of electrons are donated by the three ligands in the complex ion formed?

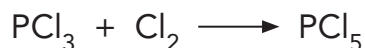
e. Which of the following options cannot form a complex with cobalt? Explain your answer.

$\ddot{\text{N}}\text{H}_3$ CH_3CH_3 $\text{H}_2\ddot{\text{O}}$ (Shade the correct answer)

Explanation: _____

Question 2 continued

- 17) The following equation is for the reaction between phosphorus trichloride and chlorine:



The following table shows the results of three experiments to investigate the rate of this reaction. All three experiments were carried out at the same temperature.

Experiment No.	$[\text{PCl}_3]/\text{mol dm}^{-3}$	$[\text{Cl}_2]/\text{mol dm}^{-3}$	Rate/ $\text{mol dm}^{-3}\text{s}^{-1}$
1	0.36	1.26	6.0×10^{-4}
2	0.36	0.63	1.5×10^{-4}
3	0.72	1.26	12×10^{-4}

- a. Explain the meaning of each of the following terms:

(i) Rate equation:

(ii) Order of reaction:

(iii) Half-life of a reaction:

- b. Use the results in table to work out the order of the forward reaction with respect to:

(i) Phosphorus trichloride (PCl_3): _____

(ii) Chlorine (Cl_2): _____

- c. Write the rate equation for this reaction.

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Question 2 continued

18) For the reaction below:



The following rate data were collected:

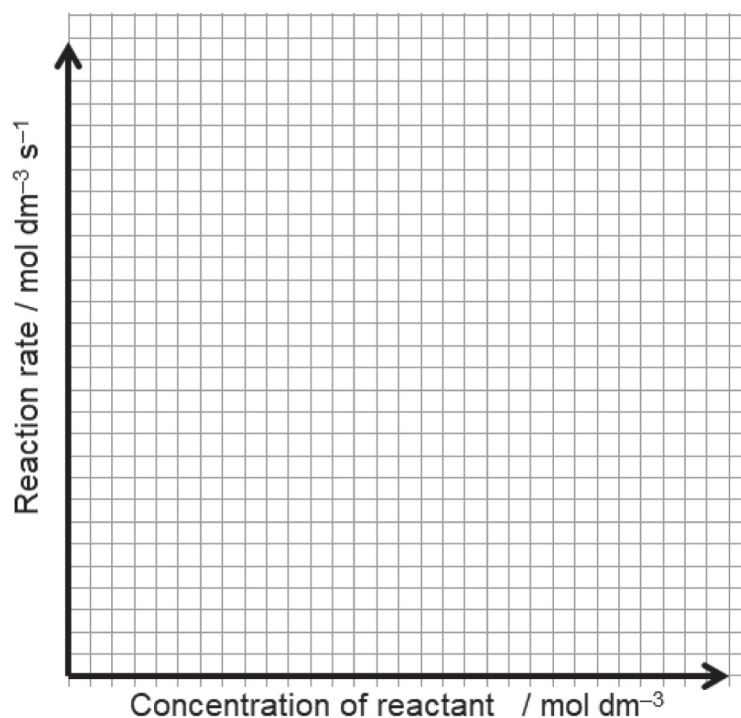
$$\text{rate} = k [\text{NO}]^2 [\text{H}_2]^0$$

Initial $[\text{NO}]/\text{mol dm}^{-3}$	Initial $[\text{H}_2]/\text{mol dm}^{-3}$	Initial rate/ $\text{mol dm}^{-3} \text{s}^{-1}$
0.60	0.37	3.0×10^{-3}

a. What is the overall order of this reaction?

b. Calculate the value of the rate constant for the forward reaction and give its unit.

c. On the axes below sketch a graph to show how changes in the concentration of the reactant affect the rate of this reaction.



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Question 2 continued

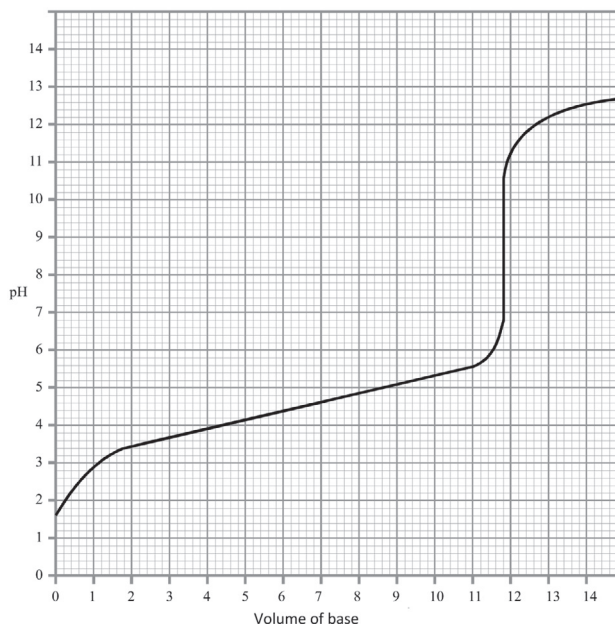
19) A $0.150 \text{ mol dm}^{-3}$ solution of ethanoic acid, CH_3COOH , has $[\text{H}^+]$ of $0.005 \text{ mol dm}^{-3}$ at 25°C .

a. Write an expression for the ethanoic acid dissociation constant, K_a .

b. State a factor that affects the value of K_a .

c. Calculate the value of $\text{p}K_a$ for this acid.

20) The following graph shows the pH curve for the titration of an acid and a base. Study it to answer the question below:



a. Define the term chemical equilibrium.

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Question 2 continued

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b. What is the equivalence point of this titration?

c. Methyl yellow is an indicator with a pH range 2.9 – 4.0. Is this indicator suitable for the above titration? Explain your answer.

21) A buffer solution contains $0.080 \text{ mol dm}^{-3}$ of hydrofluoric acid (HF), ($K_a = 5.6 \times 10^{-4} \text{ mol.dm}^{-3}$) and $0.060 \text{ mol dm}^{-3}$ sodium fluoride (NaF). In a total volume 1 dm^3 of solution.

a. Define the term buffer solution.

b. Calculate the pH after 0.05 mol dm^{-3} of sodium hydroxide (NaOH) is added to 1 dm^3 of this buffer.

c. When a small amount of hydrochloric acid (HCl) is added to this buffer solution:

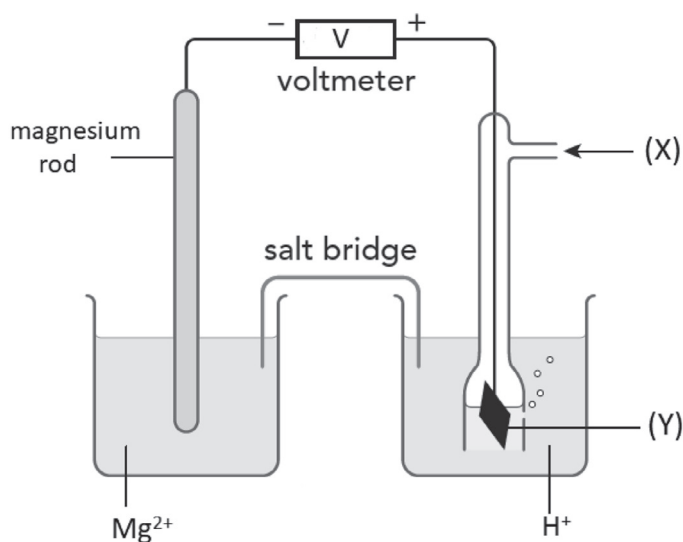
(i) Explain how this buffer solution acts when hydrochloric acid is added.

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Question 2 continued

- (ii) Write an equation which shows how this buffer solution reacts with the added hydrochloric acid.

- 22) The Mg^{2+}/Mg half-cell is connected to the standard hydrogen electrodes in the other half-cell as shown below:



- a. For the standard hydrogen electrode:

- (i) State three standard conditions.

- (ii) Write the formula of the labeled (X).

- (iii) Write the name of the part labeled (Y).

- (iv) Why is the standard hydrogen electrode needed in this cell?

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Question 2 continued

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- b. Write the half-equation for the reaction that occurs in Mg^{2+}/Mg half-cell.

- c. What is the direction of electron flow in this electrochemical cell?

- d. What would happen to the mass of magnesium electrode during the reactions that occur in this cell? Explain your answer.

- e. Write the cell notation for this cell.

- f. Calculate the E^θ value for this cell.

- 23) A molten salt of potassium chloride was electrolyzed using an electrochemical cell with inert electrodes. Answer the following questions:

- a. Write the half-equation for the reaction that occurs in:

The anode: _____

The cathode: _____

- b. What substance is liberated during this electrolysis in:

The anode: _____

The cathode: _____

[End of the Examination]

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PERIODIC TABLE OF THE ELEMENTS

1 H 1.008 Hydrogen	2 He 4.002602 Helium	<p>Atomic Number → 1</p> <p>Symbol → H</p> <p>1.008 ← Atomic Mass</p> <p>Hydrogen ← Name</p>																																																																																																		
3 Li 6.94 Lithium	4 Be 9.0121831 Beryllium	5 B 10.81 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998403163 Fluorine	10 Ne 20.1797 Neon	11 Na 22.98976928 Sodium	12 Mg 24.305 Magnesium	13 Al 26.9815385 Aluminum	14 Si 28.085 Silicon	15 P 30.973761998 Phosphorus	16 S 32.06 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.948 Argon	19 K 39.0983 Potassium	20 Ca 40.078 Calcium	21 Sc 44.955908 Scandium	22 Ti 47.867 Titanium	23 V 50.9415 Vanadium	24 Cr 51.9961 Chromium	25 Mn 54.938044 Manganese	26 Fe 55.845 Iron	27 Co 58.933194 Cobalt	28 Ni 58.6934 Nickel	29 Cu 63.546 Copper	30 Zn 65.38 Zinc	31 Ga 69.723 Gallium	32 Ge 72.630 Germanium	33 As 74.921595 Arsenic	34 Se 78.971 Selenium	35 Br 79.904 Bromine	36 Kr 83.798 Krypton	37 Rb 85.4678 Rubidium	38 Sr 87.62 Strontium	39 Y 88.90584 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.90637 Niobium	42 Mo 95.95 Molybdenum	43 Tc 98 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.90550 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.8682 Silver	48 Cd 112.414 Cadmium	49 In 114.818 Indium	50 Sn 118.710 Tin	51 Sb 121.760 Antimony	52 Te 127.60 Tellurium	53 I 126.90447 Iodine	54 Xe 131.293 Xenon	55 Cs 132.90545196 Caesium	56 Ba 137.327 Barium	57 La 138.90547 Lanthanum	58 Ce 140.116 Cerium	59 Pr 140.90766 Praseodymium	60 Nd 144.242 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92535 Terbium	66 Dy 162.500 Dysprosium	67 Ho 164.93033 Holmium	68 Er 167.259 Erbium	69 Tm 168.93422 Thulium	70 Yb 173.054 Ytterbium	71 Lu 174.9668 Lutetium	72 Hf 178.49 Hafnium	73 Ta 180.94788 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.217 Iridium	78 Pt 195.084 Platinum	79 Au 196.966569 Gold	80 Hg 200.592 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98040 Bismuth	84 Po 209 Polonium	85 At 210 Astatine	86 Rn 222 Radon	87 Fr 223 Francium	88 Ra 226 Radium	89 Ac 227 Actinium	90 Th 232.0377 Thorium	91 Pa 231.03588 Protactinium	92 U 238.02891 Uranium	93 Np 237 Neptunium	94 Pu 244 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 266 Lawrencium
																		104 Rf 267 Rutherfordium	105 Db 268 Dubnium	106 Sg 269 Seaborgium	107 Bh 270 Bohrium	108 Hs 269 Hassium	109 Mt 278 Meitnerium	110 Ds 281 Darmstadtium	111 Rg 281 Roentgenium	112 Cn 285 Copernicium	113 Uut 286 Ununtrium	114 Fl 289 Flerovium	115 Uup 289 Ununpentium	116 Lv 293 Livermorium	117 Uus 294 Ununseptium	118 Uuo 294 Ununoctium																																																																				
																		Lanthanide Series										Actinide Series																																																																								

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Electrode reaction	E^{\ominus}/V
$F_2 + 2e^- \rightleftharpoons 2F^-$	+2.87
$S_2O_8^{2-} + 2e^- \rightleftharpoons 2SO_4^{2-}$	+2.01
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1.77
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.52
$PbO_2 + 4H^+ + 2e^- \rightleftharpoons Pb^{2+} + 2H_2O$	+1.47
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33
$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+1.23
$Br_2 + 2e^- \rightleftharpoons 2Br^-$	+1.07
$ClO^- + H_2O + 2e^- \rightleftharpoons Cl^- + 2OH^-$	+0.89
$NO_3^- + 10H^+ + 8e^- \rightleftharpoons NH_4^+ + 3H_2O$	+0.87
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$	+0.81
$Ag^+ + e^- \rightleftharpoons Ag$	+0.80
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77
$I_2 + 2e^- \rightleftharpoons 2I^-$	+0.54
$O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$	+0.40
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2 + 2H_2O$	+0.17
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+0.15
$S_4O_6^{2-} + 2e^- \rightleftharpoons 2S_2O_3^{2-}$	+0.09
$2H^+ + 2e^- \rightleftharpoons H_2$	0.00
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	-0.13
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	-0.14
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	-0.44
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	-0.76
$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$	-0.83
$V^{2+} + 2e^- \rightleftharpoons V$	-1.20
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	-2.38
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	-2.87
$K^+ + e^- \rightleftharpoons K$	-2.92

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مركز القياس والتقويم التربوي
The Center for Educational Assessment
and Measurement (CEAM)



سَلْطَنَةُ عُمَانِ
وَزَارَةُ التَّحْقِيقِ وَالتَّجْوِيزِ

امتحان دبلوم التعليم العام للمدارس الخاصة (ثنائية اللغة)

للعام الدراسي ١٤٤٣ هـ - ٢٠٢١ / ٢٠٢٢ م

الدور الأول - الفصل الدراسي الثاني

- زمن الإجابة: ثلاث ساعات.
- الإجابة في الورقة نفسها.

- تنبيه: المادة: الكيمياء.
- الأسئلة في (١٦) صفحة.

تعليمات مهمة:

- يجب على الممتحن التأكد من استلام دفتر امتحانه، مغلفاً بغلاف بلاستيكي شفاف وغير ممزق، وهو مسؤول عنه حتى يسلمه لمراقبي اللجنة بعد الانتهاء من الإجابة.
- يجب الالتزام بضوابط إدارة امتحانات دبلوم التعليم العام وما في مستواه وأية مخالفة لهذه الضوابط تعرضك للتدابير والإجراءات والعقوبات المنصوص عليها بالقرار الوزاري رقم ٥٨٨ / ٢٠١٥.
- يقوم المتقدم بالإجابة عن أسئلة الامتحان المقالية بقلم الحبر (الأزرق أو الأسود).
- يقوم المتقدم بالإجابة عن أسئلة الاختيار من متعدد بتظليل الشكل (□) وفق النموذج الآتي:
س - عاصمة سلطنة عمان هي:
□ القاهرة □ الدوحة
■ مسقط □ أبوظبي
- ملاحظة: يتم تظليل الشكل (■) باستخدام القلم الرصاص وعند الخطأ، امسح بعناية لإجراء التغيير.
- يجب على الممتحن اصطحب الهواتف النقالة وأجهزة النداء الآلي وألات التصوير والحواسيب الشخصية والساعات الرقمية الذكية والآلات الحاسبة ذات الذاكرة التخزينية والمجلات والصحف والكتب الدراسية والدفاتر والمذكرات والحقائب اليدوية والآلات الحادة أو الأسلحة أياً كان نوعها وأي شيء له علاقة بالامتحان.
- يجب على الممتحن الامتنال لإجراءات التفطيش داخل المركز طوال أيام الامتحان.

صحيح ■ غير صحيح □



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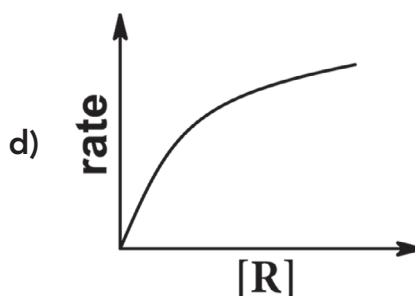
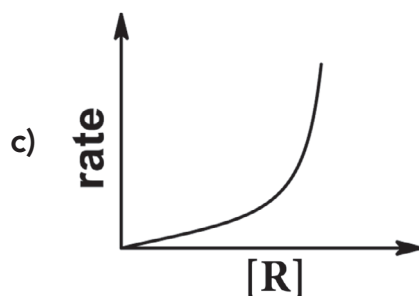
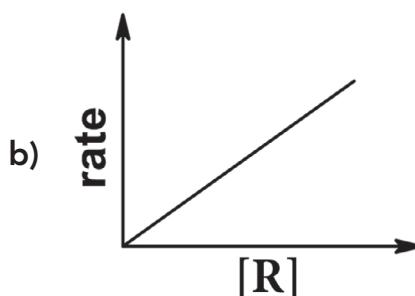
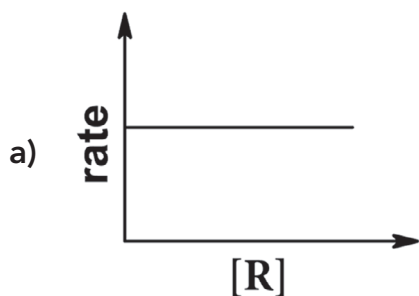
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Question 1 continued

5) In which reaction are the values of ΔH_f and ΔH_c not equal?

- $C(s) + O_2(g) \rightleftharpoons CO_2(g)$
- $2Mg(s) + O_2(g) \rightleftharpoons 2MgO(s)$
- $H_2(g) + \frac{1}{2} O_2(g) \rightleftharpoons H_2O(g)$
- $2Na(s) + \frac{1}{2} O_2(g) \rightleftharpoons Na_2O(s)$

6) In the graphs below, the rate was plotted against the reactant [R].



Which of the following options is correct?

	Graph that represents the second-order reaction	Rate expression with respect to R
<input type="checkbox"/>	a	Rate = $k[R]^0$
<input type="checkbox"/>	b	Rate = $k[R]^2$
<input type="checkbox"/>	c	Rate = $k[R]^2$
<input type="checkbox"/>	d	Rate = $k[R]^0$

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Question 1 continued

- 7) The table below shows the experimental data for the following reaction.



Experiment	$[\text{NO}_2]/\text{mol dm}^{-3}$	$[\text{CO}]/\text{mol dm}^{-3}$	Initial rate/ $\text{mol dm}^{-3} \text{ s}^{-1}$
1	0.10	0.10	1.0×10^{-6}
2	0.30	0.10	9.0×10^{-6}
3	0.30	0.30	9.0×10^{-6}

Which of the following options represents the rate of this reaction according to the experimental data?

- Rate = $k[\text{NO}_2]^1 [\text{CO}]^1$ Rate = $k[\text{NO}_2]^0 [\text{CO}]^2$
 Rate = $k[\text{NO}_2]^2 [\text{CO}]^0$ Rate = $k[\text{NO}_2]^3 [\text{CO}]^0$
- 8) Which of the following is correct in a neutral solution at 25 °C?
- K_w is equal to $[\text{H}_3\text{O}^+][\text{OH}^-]$.
 $[\text{H}_3\text{O}^+]$ is greater than $[\text{OH}^-]$.
 K_w value is $1.0 \times 10^{-7} \text{ mol}^2 \text{ dm}^{-6}$.
 $[\text{OH}^-]$ value is $1.0 \times 10^{-14} \text{ mol dm}^{-3}$.

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Question 1 continued

- 9) Which of the following options about K_a and pK_a values are correct as the acidity increases?

	K_a	pK_a
<input type="radio"/>	increases	increases
<input type="radio"/>	decreases	decreases
<input type="radio"/>	increases	decreases
<input type="radio"/>	decreases	increases

Use the following information to answer questions 10 and 11:

Sulfurous acid dissociates as follows:



- 10) What is the K_a unit for sulfurous acid dissociation?

- $\text{mol}^2 \text{dm}^{-6}$ mol dm^{-3}
 $\text{mol}^{-2} \text{dm}^6$ $\text{mol}^{-1} \text{dm}^3$

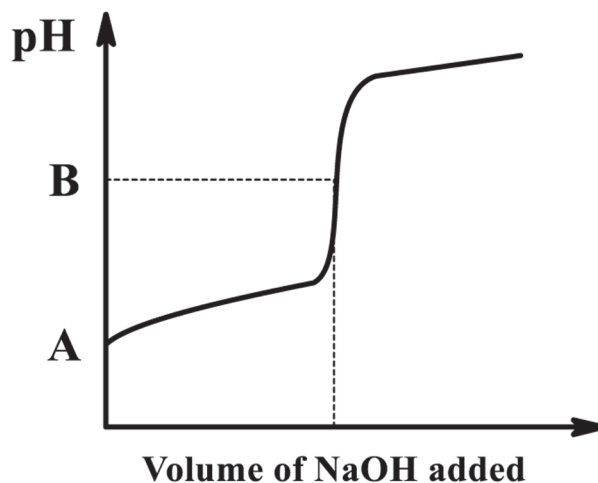
- 11) The $[\text{H}^+]$ equals to:

- $\frac{K_a[\text{HSO}_3^-]}{[\text{H}_2\text{SO}_3]}$ $\frac{[\text{HSO}_3^-]}{K_a[\text{H}_2\text{SO}_3]}$
 $\frac{K_a[\text{H}_2\text{SO}_3]}{[\text{HSO}_3^-]}$ $\frac{[\text{H}_2\text{SO}_3]}{K_a[\text{HSO}_3^-]}$

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Question 1 continued

- 12) The graph below shows the change in pH when a solution of sodium hydroxide (NaOH) is added from a burette to 25.00 cm³ of a 0.15 mol dm⁻³ solution of the weak acid HA ($K_a = 5.6 \times 10^{-4}$ mol dm⁻³ at 25 °C).



Which of the following options is correct about the value of A and B?

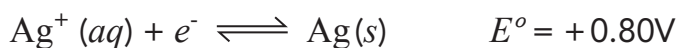
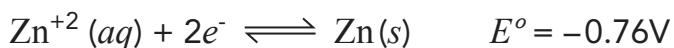
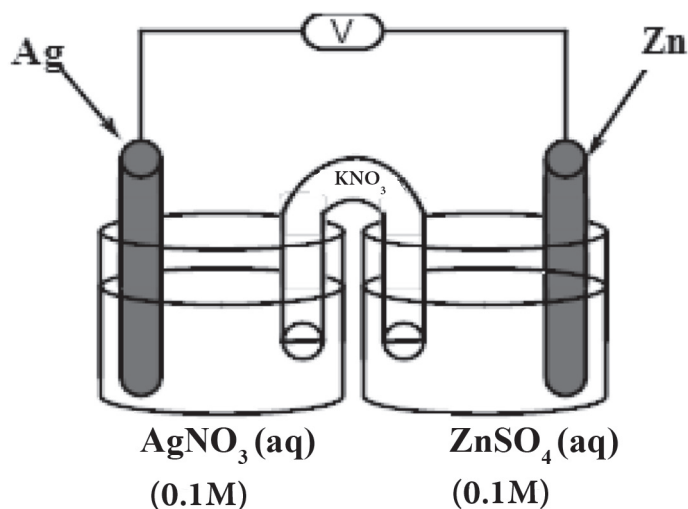
	A	B
<input type="radio"/>	4.0	9.0
<input type="radio"/>	4.0	5.0
<input type="radio"/>	2.0	5.0
<input type="radio"/>	2.0	9.0

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Question 1 continued

The diagram below shows an electrochemical cell at standard conditions.

Study it to answer questions (13) and (14).



13) Which of the following statements is correct?

- Ag^{+} is a reducing agent in this cell to be feasible.
- Zn is an oxidizing agent in this cell to be feasible.
- Electrons will flow from Zn to Ag.
- Electrons will flow from Ag to Zn.

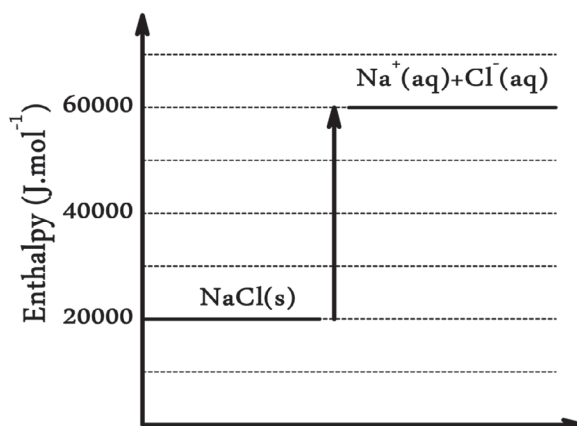
14) What is the standard electromotive force E^{θ} cell for this cell?

- 0.04 V + 0.04 V
- 1.56 V + 1.56 V

Question 2: Extended responses**(56 marks)**

Write your answer for each of the following questions in the space provided.
Be sure to show all your work, including the correct units where applicable.

- 15) The diagram shows the enthalpy change of dissolving 5.85 g of sodium chloride (NaCl) in water. Study it and answer the questions below.



- a. What is meant by the lattice solution enthalpy?

- b. What type is this reaction?

Exothermic

Endothermic

(shade your answer)

Explain: _____

- c. Calculate the final temperature in °C if the initial temperature was 26°C

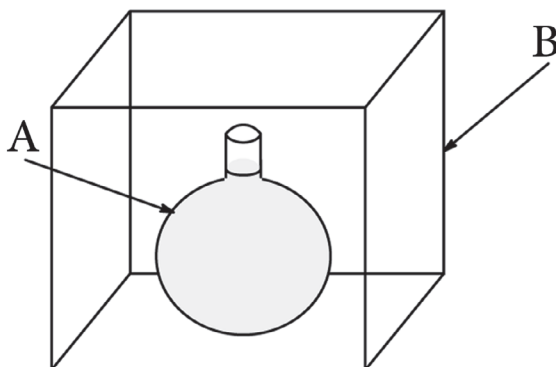
(Mr of NaCl = 58.5 g/mol, $c = 4.18 \text{ J} \cdot \text{g}^{-1} \cdot \text{°C}^{-1}$, mass of $\text{H}_2\text{O} = 500 \text{ g}$)

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Question 2 continued

16) a. What is meant by the endothermic reaction?

b. Study the figure of an exothermic reaction below and answer the following questions.



(i) Complete the table below:

Term	Letter
System	_____
Surrounding	_____

(ii) The energy flows

A to B

B to A

(shade your answer)

c. If the energy released by the system is about 111 J and the energy absorbed about 232 J, calculate the value of ΔH in Joule (J)?

d. If the temperature of the surrounding is decreased, the ΔH of the system will be:

Positive

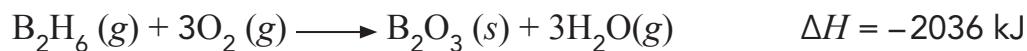
Negative

(shade your answer)

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Question 2 continued

- 17) The three equations below represent the three stages of reaction for the formation of B_2H_6 gas.



Study them and answer the questions.

- a. Define Hess law.

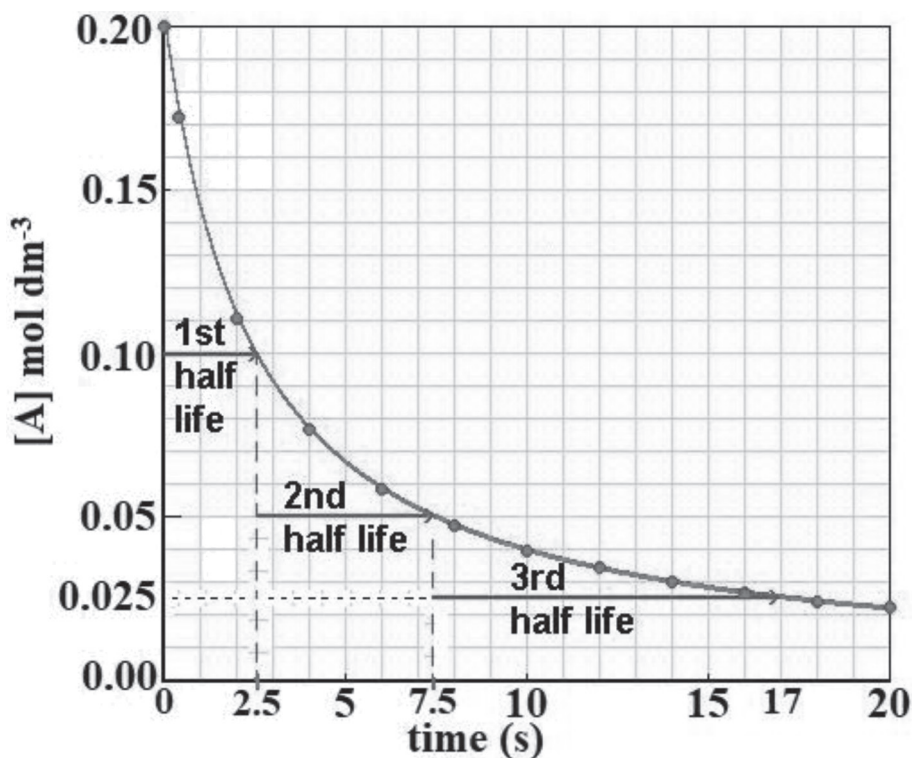
- b. Calculate: ΔH_f of $H_2O(g)$ in $KJ.mol^{-1}$

- c. Calculate ΔH of the equation $2B(s) + 3H_2(g) \longrightarrow B_2H_6(g)$

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Question 2 continued

- 18) a. The graph below shows a curve where $[A]$ was plotted against time for a reaction. This method is called the half-life of the reaction. It is used to check the order of a reaction and measure its rate.



- (i) What is meant by the term order of the reaction?

- (ii) What is meant by the term the half-life of the reaction?

- (iii) Suggest another method to check the order of a reaction and measure its rate.

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Question 2 continued

- b. Write the expression for the rate of this reaction with respect to [A].

- c. Using the data in the graph, what is the order of this reaction with respect to [A]?

Zero order First order Second order (shade your answer)

Explanation: _____

- d. Using the data in the above graph, to calculate the following:

- (i) The rate of this reaction with respect to [A] from the beginning to the end of the third half-life. (Show the units)

- (ii) The rate constant (K) of this reaction with respect to [A] at the end of the third half-life. (Show the units)

- 19) The value of the acid dissociation constant, K_a , for hydrocyanic acid (HCN) is $4.9 \times 10^{-10} \text{ mol.dm}^{-3}$ at 25°C .

- a. Write an expression for K_a for hydrocyanic acid.

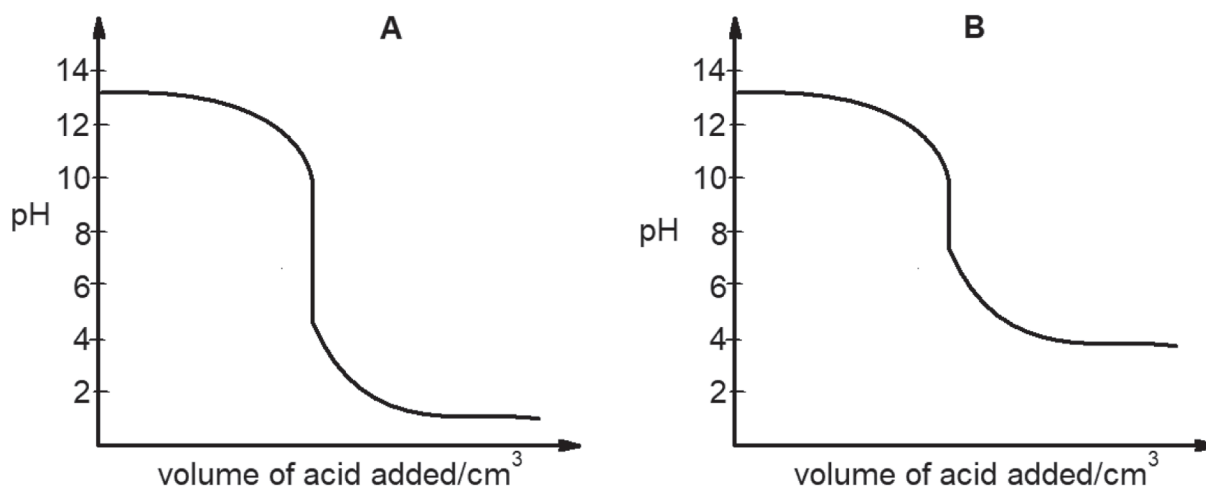
- b. State a factor that affects the value of K_a ?

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Question 2 continued

- c. Calculate the pH of a 0.25 mol dm^{-3} solution of hydrocyanic acid.

- 20) Titration curves labelled A and B for combinations of different acids and bases are shown below:



- a. What type is each titration in term of strength of acid and base?

-Titration curve A: _____

-Titration curve B: _____

- b. What is the equivalence point of each titration?

-Titration curve A: _____

-Titration curve B: _____

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Question 2 continued

- c. A list of indicators is shown below:

Name of indicator	pH range
Phenolphthalein	8.2 – 10.0
methyl red	4.4 – 6.2
bromothymol blue	6.0 – 7.6
methyl orange	3.2 – 4.4

Select from the list the most suitable indicator for both titrations **A** and **B**. and explain your choice.

Indicator: _____

Explanation: _____

- 21) A buffer solution is prepared by adding 100 cm^3 of 0.30 mol dm^{-3} methanoic acid, HCO_2H ($K_a = 1.6 \times 10^{-4} \text{ mol.dm}^{-3}$) to 100 cm^3 of 0.30 mol dm^{-3} sodium methanoate, NaCO_2H .

- a. Define the term buffer solution.

- b. Calculate the pH of this buffer solution.

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Question 2 continued

- c. Calculate the pH when 0.01 mol of hydrochloric acid (HCl) is added to 200 cm³ of this buffer solution.

- d. When a small amount of sodium hydroxide (NaOH) is added to this buffer solution:

- (i) Explain how this buffer solution acts when sodium hydroxide is added.

- (ii) Write an equation which shows how this buffer solution reacts with the added sodium hydroxide.

Question 2 continued

22) Use the data in the table below to answer the questions below.

Standard electrode potentials	$E^0(\text{V})$
$\text{Fe}^{3+}(\text{aq}) + e^- \rightleftharpoons \text{Fe}^{2+}(\text{aq})$	+0.77
$\text{Cl}_2(\text{g}) + 2e^- \rightleftharpoons 2\text{Cl}^-(\text{aq})$	+1.36
$2\text{BrO}_3^-(\text{aq}) + 12\text{H}^+(\text{aq}) + 10e^- \rightleftharpoons \text{Br}_2(\text{aq}) + 6\text{H}_2\text{O}(\text{l})$	+1.52
$\text{O}_3(\text{g}) + 2\text{H}^+(\text{aq}) + 2e^- \rightleftharpoons \text{O}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$	+2.08
$\text{F}_2\text{O}(\text{g}) + 2\text{H}^+(\text{aq}) + 4e^- \rightleftharpoons 2\text{F}^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+2.15

a. Identify the most powerful reducing agent in the table.

b. Identify the most powerful oxidizing agent in the table.

c. Identify all the species in the table which can be oxidized by $\text{BrO}_3^-(\text{aq})$

23) From your electrochemical cell study. Answer the following questions:

a. (i) Write a cell diagram for: $\text{Cr}^{3+}(\text{aq})/\text{Cr}^{2+}(\text{aq})(E^0(\text{V}) = -0.41)$ half-cell compared with a copper half-cell ($E^0(\text{V}) = +0.34$).

(ii) Calculate E^0 cell for the above cell.

(iii) Is this reaction feasible? Explain your answer.

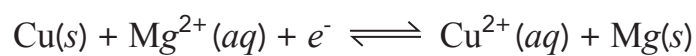
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Question 2 continued

- b. For the E^0 values and reaction shown below.

$$E^0(\text{Cu}^{2+}/\text{Cu}) = +0.34 \text{ V}$$

$$E^0(\text{Mg}^{2+}/\text{Mg}) = -2.37 \text{ V}$$



Calculate E^0_{cell} for this reaction.

[End of Examination]

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PERIODIC TABLE OF THE ELEMENTS

1 H 1.008 Hydrogen	2 He 4.002602 Helium	<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center; margin-right: 10px;"> Atomic Number → 1 ↓ Symbol → H ↓ 1.008 ← Atomic Mass Hydrogen ← Name </div> </div>																																																																																																		
3 Li 6.94 Lithium	4 Be 9.0121831 Beryllium	5 B 10.81 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998403163 Fluorine	10 Ne 20.1797 Neon	11 Na 22.98976928 Sodium	12 Mg 24.305 Magnesium	13 Al 26.9815385 Aluminum	14 Si 28.085 Silicon	15 P 30.973761998 Phosphorus	16 S 32.06 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.948 Argon	19 K 39.0983 Potassium	20 Ca 40.078 Calcium	21 Sc 44.955908 Scandium	22 Ti 47.867 Titanium	23 V 50.9415 Vanadium	24 Cr 51.9961 Chromium	25 Mn 54.938044 Manganese	26 Fe 55.845 Iron	27 Co 58.933194 Cobalt	28 Ni 58.6934 Nickel	29 Cu 63.546 Copper	30 Zn 65.38 Zinc	31 Ga 69.723 Gallium	32 Ge 72.630 Germanium	33 As 74.921595 Arsenic	34 Se 78.971 Selenium	35 Br 79.904 Bromine	36 Kr 83.798 Krypton	37 Rb 85.4678 Rubidium	38 Sr 87.62 Strontium	39 Y 88.90584 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.90637 Niobium	42 Mo 95.95 Molybdenum	43 Tc 98 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.90550 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.8682 Silver	48 Cd 112.414 Cadmium	49 In 114.818 Indium	50 Sn 118.710 Tin	51 Sb 121.760 Antimony	52 Te 127.60 Tellurium	53 I 126.90447 Iodine	54 Xe 131.293 Xenon	55 Cs 132.90545196 Caesium	56 Ba 137.327 Barium	57 La 138.90547 Lanthanum	58 Ce 140.116 Cerium	59 Pr 140.90766 Praseodymium	60 Nd 144.242 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92535 Terbium	66 Dy 162.500 Dysprosium	67 Ho 164.93033 Holmium	68 Er 167.259 Erbium	69 Tm 168.93422 Thulium	70 Yb 173.054 Ytterbium	71 Lu 174.9668 Lutetium	72 Hf 178.49 Hafnium	73 Ta 180.94788 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.217 Iridium	78 Pt 195.084 Platinum	79 Au 196.966569 Gold	80 Hg 200.592 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98040 Bismuth	84 Po 209 Polonium	85 At 210 Astatine	86 Rn 222 Radon	87 Fr 223 Francium	88 Ra 226 Radium	89 Ac 227 Actinium	90 Th 232.0377 Thorium	91 Pa 231.03688 Protactinium	92 U 238.02891 Uranium	93 Np 237 Neptunium	94 Pu 244 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 266 Lawrencium

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مركز القياس والتقويم التربوي
The Center for Educational Assessment
and Measurement (CEAM)



سَلْطَنَةُ عَمَانَ
وَزَارَةُ التَّحْقِيقِ وَالتَّجْوِيزِ

امتحان دبلوم التعليم العام للمدارس الخاصة (ثنائية اللغة)

للعام الدراسي ١٤٤٣ هـ - ٢٠٢١ / ٢٠٢٢ م

الدور الثاني - الفصل الدراسي الثاني

- زمن الإجابة: ثلاث ساعات.
- الإجابة في الورقة نفسها.

- تنبيه: المادة: الكيمياء.
- الأسئلة في (١٣) صفحة.

تعليمات مهمة:

- يجب على الممتحن التأكد من استلام دفتر امتحانه، مغلفاً بغلاف بلاستيكي شفاف وغير ممزق، وهو مسؤول عنه حتى يسلمه لمراقبي اللجنة بعد الانتهاء من الإجابة.
- يجب الالتزام بضوابط إدارة امتحانات دبلوم التعليم العام وما في مستواه وأية مخالفة لهذه الضوابط تعرضك للتدابير والإجراءات والعقوبات المنصوص عليها بالقرار الوزاري رقم ٥٨٨ / ٢٠١٥.
- يقوم المتقدم بالإجابة عن أسئلة الامتحان المقالية بقلم الحبر (الأزرق أو الأسود).
- يقوم المتقدم بالإجابة عن أسئلة الاختيار من متعدد بتظليل الشكل () وفق النموذج الآتي:
س - عاصمة سلطنة عمان هي:
 القاهرة الدوحة
 مسقط أبوظبي
- ملاحظة: يتم تظليل الشكل () باستخدام القلم الرصاص وعند الخطأ، امسح بعناية لإجراء التغيير.
- يجب على الممتحن اصطحب الهوية وإبرازها للعاملين بالامتحانات.
- يجب إحضار أصل ما يثبت الهوية (الهداشة البيضاء والمصر أو الكمة للذكور) والزي المدرسي للطالبات، ويستثنى من ذلك الدارسون من غير العمانيين بشرط الالتزام بالذوق العام، ويمنع على جميع المتقدمين ارتداء النقاب داخل المركز وقاعات الامتحان.
- يحظر على الممتحنين اصطحاب الهواتف النقالة وأجهزة النداء الآلي وألات التصوير والحواسيب الشخصية والساعات الرقمية الذكية والآلات الحاسبة ذات الذاكرة التخزينية والمجلات والصحف والكتب الدراسية والدفاتر والمذكرات والحقائب اليدوية والآلات الحادة أو الأسلحة أياً كان نوعها وأي شيء له علاقة بالامتحان.
- يجب على الممتحن الامتثال لإجراءات التفطيش داخل المركز طوال أيام الامتحان.

صحيح غير صحيح

مُسَوِّدَةٌ، لَا يَتَمُّ تَصْحِيحُهَا

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Question 1: Multiple Choice Items**(14 marks)**

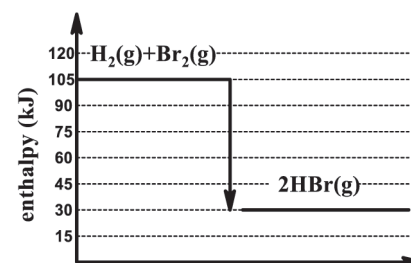
There are 14 multiple-choice items worth one mark each.

Shade in the bubble () next to the **correct** answer for each of the following items.

- 1) Which of the following statements is not correct about Hess's law?
- Reaction can occur in more than one route
 - The overall enthalpy change in the steps = enthalpy change in the main reaction
 - It is not necessary to consider the number of moles in the summation of the reaction
 - The physical statements must be considered.
- 2) Which reaction shows the ΔH of neutralization?
- $\text{H}_2 + \text{Cl}_2 \longrightarrow 2\text{HCl}$
 - $2\text{CO} + \text{O}_2 \longrightarrow 2\text{CO}$
 - $2\text{MgO} \longrightarrow 2\text{Mg} + \text{O}_2$
 - $2\text{HCl} + \text{Ca}(\text{OH})_2 \longrightarrow \text{CaCl}_2 + 2\text{H}_2\text{O}$
- 3) If 3 moles of carbon react with a sufficient amount of oxygen producing carbon dioxide and energy of 1180.5 kJ. What is the value of ΔH_{comp} of carbon in $\text{kJ}\cdot\text{mol}^{-1}$?
- 393.5
 - 3541.5
 - 393.5
 - 3541.5
- 4) The energy enthalpy diagram below shows the enthalpy change of the reaction when producing hydrogen bromide gas.

The value of ΔH_f of HBr in $\text{kJ}\cdot\text{mol}^{-1}$ is equal to:

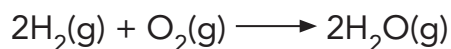
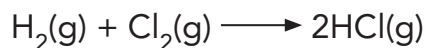
- 105
- 75
- 50.25
- 37.5



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Question 1 continued

5. Consider the following two steps of a reaction:



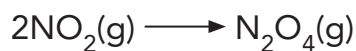
Which of the following reactions, represents the final main reaction of the two steps?

- $4\text{HCl}(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{Cl}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$
- $4\text{HCl}(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{Cl}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$
- $4\text{HCl}(\text{aq}) + \text{O}_2(\text{g}) \longrightarrow 2\text{Cl}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$
- $4\text{HCl}(\text{g}) + 2\text{O}_2(\text{g}) \longrightarrow 2\text{Cl}_2(\text{g}) + 2\text{H}_2\text{O}_2(\text{g})$

6. Which of the following statements is correct about the rate of a reaction?

- It always has a positive value.
- It is always independent of all the reactants.
- It can be measured by chemical analysis only.
- It shows how the concentration of a reactant increases.

7. Which of the following expressions is correct for the reaction below?



$$1 \quad \text{Rate} = \frac{-\Delta[\text{NO}_2]}{\Delta t} = \frac{2\Delta[\text{N}_2\text{O}_4]}{\Delta t}$$

$$2 \quad \text{Rate} = \frac{-\Delta[\text{NO}_2]}{\Delta t} = \frac{1}{2} \frac{\Delta[\text{N}_2\text{O}_4]}{\Delta t}$$

$$3 \quad \frac{-\Delta[\text{NO}_2]}{\Delta t} = \frac{+\Delta[\text{N}_2\text{O}_4]}{\Delta t}$$

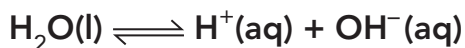
$$4 \quad \frac{-\Delta[\text{NO}_2]}{\Delta t} \neq \frac{+\Delta[\text{N}_2\text{O}_4]}{\Delta t}$$

- 1 and 2 only
- 3 and 4 only
- 1 and 4 only
- 2 and 3 only

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Question 1 continued

Water dissociates as follows:



Use it to answer questions (8 and 9):

8) What is the unit of K_w ?

$\text{mol}^{-1} \text{dm}^3$

mol dm^{-3}

$\text{mol}^{-2} \text{dm}^6$

$\text{mol}^2 \text{dm}^{-6}$

9) What is the value of K_w at 25 °C?

1.0×10^{-4}

1.0×10^{-7}

1.0×10^{-12}

1.0×10^{-14}

10) What is the concentration of H^+ ion in a 0.50 mol dm^{-3} solution of sodium hydroxide?

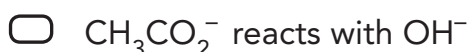
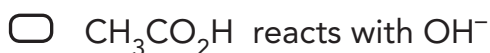
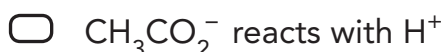
$2.0 \times 10^{-7} \text{ mol dm}^{-3}$

$2.0 \times 10^{-14} \text{ mol dm}^{-3}$

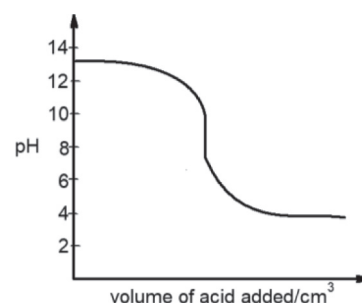
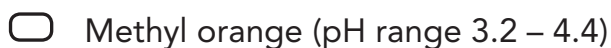
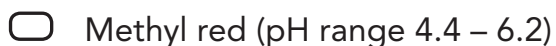
$5.0 \times 10^{-6} \text{ mol dm}^{-3}$

$5.0 \times 10^{-13} \text{ mol dm}^{-3}$

11) Which of the following is correct when a small amount of calcium hydroxide solution is added to a buffer solution of $(\text{CH}_3\text{CO}_2\text{H} / \text{CH}_3\text{CO}_2\text{Na})$?



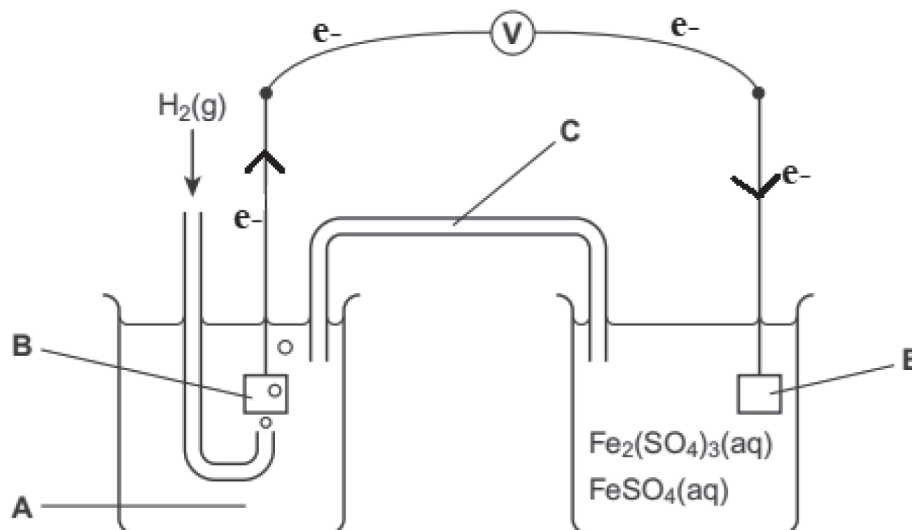
12) For the titration curve shown below, what is the most suitable indicator for this titration?



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Question 1 continued

The diagram below shows a cell that can be used to measure the standard electrode potential for the half-reaction $\text{Fe}^{3+}(\text{aq}) + \text{e}^{-} \longrightarrow \text{Fe}^{2+}(\text{aq})$. Use the diagram to answer questions 13 and 14.



13) Which of the following options is correct about the solution in C?

- It is unreactive
- It can be HCl
- The cell works without it
- It does not allow moving electrons

14) Which of the following represents cell diagrams for the above cell?

- $\text{Pt} | \text{H}^{+} | \frac{1}{2} \text{H}_2 || \text{Fe}^{2+}, \text{Fe}^{3+} | \text{Pt}$
- $\text{Pt} | \frac{1}{2} \text{H}_2 | \text{H}^{+} || \text{Fe}^{3+}, \text{Fe}^{2+} | \text{Pt}$
- $\text{Pt} | \frac{1}{2} \text{H}_2 | \text{H}^{+}, \text{Fe}^{3+}, \text{Fe}^{2+} | \text{Pt}$
- $\text{Pt} | \frac{1}{2} \text{H}_2 | \text{H}^{+} || \text{Fe}^{3+}, \text{Fe}^{2+} | \text{Pd}$

Question 2: Extended responses**(56 marks)**

Write your answer for each of the following questions in the space provided.
Be sure to show all your work, including the correct units where applicable.

15. The following figure shows how the enthalpy changed with temperature by dissolving 29.4g of NaX in 1000 g of water. ($c = 4.18 \text{ J} \cdot \text{g}^{-1} \cdot \text{C}^{-1}$, Mr of Na = $23 \text{ g} \cdot \text{mol}^{-1}$)

Study it and answer the questions.

- a. In general, what is the value sign of the lattice solution enthalpy?

- Always positive
 Always negative
 Positive or negative

(shade the correct answer)

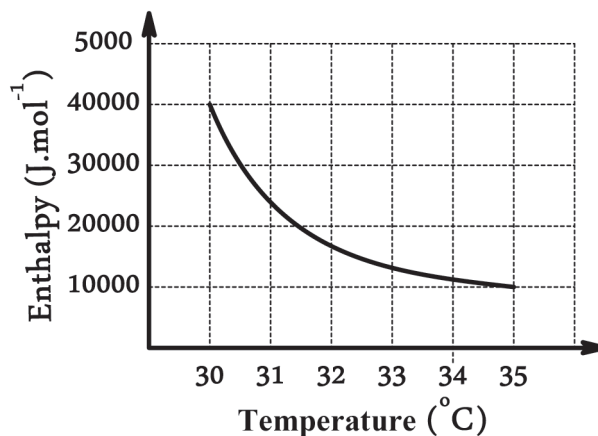
- b. What type is this reaction?

- Exothermic
 Endothermic

(shade the correct answer)

- c. Calculate the number of moles of the salt NaX

- d. What is the molecular weight of atom (X)? (Show your calculations)



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Question 2 continued

16. a. Define lattice formation enthalpy.

b. Complete the table below for the formation reactions:

Energy	Sign of energy enthalpy	Occur when
Produced	_____	Forming bonds
Absorbed	_____	_____

c. The table below shows the values of enthalpies for a specific reaction.

Energy absorbed	Energy produced
353 kJ	437 KJ

(i) Calculate the value of ΔH in kJ

(ii) In this reaction, which has more energy:

Reactants

Products

shade the correct answer

17) The equation below represents the combustion of propene gas

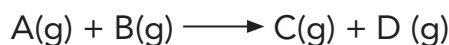


a. Define the standard enthalpy of combustion.

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Question 2 continued

18. The following data was obtained for the reaction between gas A(g) and gas B(g).



experiment	[A] / mol dm ⁻³	[B] / mol dm ⁻³	Initial rate of reaction
1	0.100	0.100	2.00 × 10 ⁻³
2	0.200	0.100	4.00 × 10 ⁻³
3	0.200	0.200	16.00 × 10 ⁻³

a. Define the term rate of reaction.

b. State one method used for studying the rate of a reaction.

c. Use the data in the table to determine the order of the reaction. Explain your answer.

Order with respect to A(g): _____

Explanation: _____

Order with respect to B(g): _____

Explanation: _____

d. Write the rate law for the reaction between A(g) and B(g).

e. Use experiment 2 to calculate a numerical value for the rate constant, k.

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Question 2 continued

- 19) The K_a values for some acids are listed below. Use them to answer the following questions.

Acid	K_a
H_2SO_3	1.3×10^{-2}
CH_3CO_2H	1.7×10^{-5}
HCN	4.9×10^{-10}

- a. Which one from the above acids is the most acidic?

- b. Which one from the above acids has the highest value of pK_a ?

- c. State a factor that affects the value of K_a .

- d. For sulfurous acid (H_2SO_3):

- (i) Write the K_a expression.

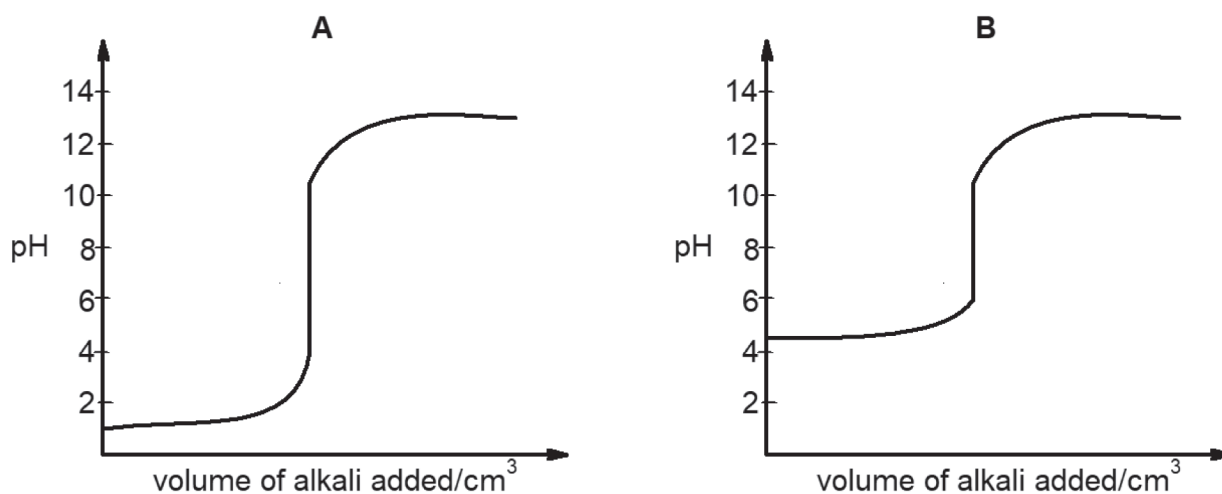
- (ii) What is the K_a unit for sulfurous acid?

- e. Calculate the pH of a 0.06 mol dm^{-3} solution of CH_3CO_2H acid.

Do not write in this space

Question 2 continued

- 20) Titration curves labelled A and B for combinations of different acids and bases are shown below:



- a. What type is each titration in terms of strength of acid and base:

-Titration curve A: _____

-Titration curve B: _____

- b. What is the equivalence point of each titration:

-Titration curve A: _____

-Titration curve B: _____

- c. Which indicator is suitable for titration A only:

Methyl orange (pH range 3.2 – 4.4).

Methyl violet (pH range 0.0 – 1.6).

(shade the correct answer)

Explain your answer _____

Question 2 continued

21) A buffer solution contains 0.25 mol dm^{-3} methanoic acid, HCO_2H ($K_a = 1.6 \times 10^{-4} \text{ mol dm}^{-3}$) and 0.30 mol dm^{-3} sodium methanoate, NaCO_2H .

a. Define the term buffer solution.

b. Calculate the pH of this buffer solution.

c. When a small amount of hydrochloric acid is added to this buffer solution:

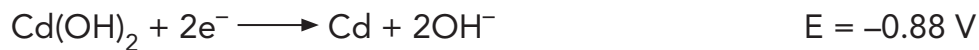
(i) Explain how this buffer solution acts with the added hydrochloric acid.

(ii) Write an equation to show how this buffer solution reacts with the added hydrochloric acid.

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Question 2 continued

- 22) Nickel–cadmium cells are used to power electrical equipment such as drills and shavers. The electrode reactions are shown below.



- a. Calculate the e.m.f. of a nickel–cadmium cell

- b. State the standard conditions

- c. (i) Identify the oxidizing agent in the Nickel– cadmium cell.

- (ii) What is the oxidation number of cadmium in Cd(OH)_2 ?

Question 2 continued

23) Use the data below to answer the following questions.

Standard electrode potentials	E^0 (V)
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \longrightarrow \text{Fe}^{2+}(\text{aq})$	+ 0.77
$2\text{BrO}_3^-(\text{aq}) + 12\text{H}^+(\text{aq}) + 10\text{e}^- \longrightarrow \text{Br}_2(\text{aq}) + 6\text{H}_2\text{O}(\text{l})$	+1.52

The cell represented below.



a. Calculate the e.m.f. of this cell.

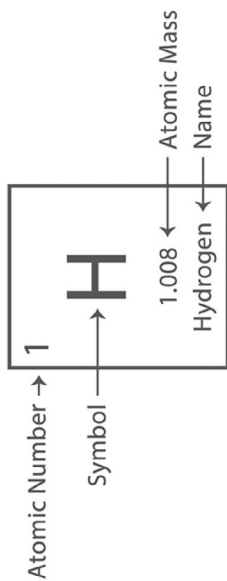
b. Write the half-equation for the reaction occurring at the negative electrode.

[End of Examination]

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PERIODIC TABLE OF THE ELEMENTS

1 H 1.008 Hydrogen	2 He 4.002602 Helium	3 Li 6.94 Lithium	4 Be 9.0121831 Beryllium	5 B 10.81 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998403163 Fluorine	10 Ne 20.1797 Neon	11 Na 22.98976928 Sodium	12 Mg 24.305 Magnesium	13 Al 26.9815385 Aluminium	14 Si 28.085 Silicon	15 P 30.973761998 Phosphorus	16 S 32.06 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.948 Argon	19 K 39.0983 Potassium	20 Ca 40.078 Calcium	21 Sc 44.955908 Scandium	22 Ti 47.867 Titanium	23 V 50.9415 Vanadium	24 Cr 51.9961 Chromium	25 Mn 54.938044 Manganese	26 Fe 55.845 Iron	27 Co 58.933194 Cobalt	28 Ni 58.6934 Nickel	29 Cu 63.546 Copper	30 Zn 65.38 Zinc	31 Ga 69.723 Gallium	32 Ge 72.630 Germanium	33 As 74.921595 Arsenic	34 Se 78.971 Selenium	35 Br 79.904 Bromine	36 Kr 83.798 Krypton	37 Rb 85.4678 Rubidium	38 Sr 87.62 Strontium	39 Y 88.90584 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.90637 Niobium	42 Mo 95.95 Molybdenum	43 Tc 98 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.90550 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.8682 Silver	48 Cd 112.414 Cadmium	49 In 114.818 Indium	50 Sn 118.710 Tin	51 Sb 121.760 Antimony	52 Te 127.60 Tellurium	53 I 126.90447 Iodine	54 Xe 131.263 Xenon	55 Cs 132.90545196 Caesium	56 Ba 137.327 Barium	57 La 138.90547 Lanthanum	58 Ce 140.116 Cerium	59 Pr 140.90766 Praseodymium	60 Nd 144.242 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92535 Terbium	66 Dy 162.500 Dysprosium	67 Ho 164.93033 Holmium	68 Er 167.259 Erbium	69 Tm 168.93422 Thulium	70 Yb 173.054 Ytterbium	71 Lu 174.9668 Lutetium	72 Hf 178.49 Hafnium	73 Ta 180.94788 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.217 Iridium	78 Pt 195.084 Platinum	79 Au 196.966569 Gold	80 Hg 200.592 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98040 Bismuth	84 Po 209 Polonium	85 At 210 Astatine	86 Rn 222 Radon	87 Fr 223 Francium	88 Ra 226 Radium	89 Ac 227 Actinium	90 Th 232.0377 Thorium	91 Pa 231.03588 Protactinium	92 U 238.02891 Uranium	93 Np 237 Neptunium	94 Pu 244 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 266 Lawrencium	104 Rf 267 Rutherfordium	105 Db 268 Dubnium	106 Sg 269 Seaborgium	107 Bh 270 Bohrium	108 Hs 269 Hassium	109 Mt 278 Meitnerium	110 Ds 281 Darmstadtium	111 Rg 281 Roentgenium	112 Cn 285 Copernicium	113 Uut 286 Ununtrium	114 Fl 289 Flerovium	115 Uup 289 Ununpentium	116 Lv 293 Livermorium	117 Uus 294 Ununseptium	118 Uuo 294 Ununoctium
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57 La 138.90547 Lanthanum	58 Ce 140.116 Cerium	59 Pr 140.90766 Praseodymium	60 Nd 144.242 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92535 Terbium	66 Dy 162.500 Dysprosium	67 Ho 164.93033 Holmium	68 Er 167.259 Erbium	69 Tm 168.93422 Thulium	70 Yb 173.054 Ytterbium	71 Lu 174.9668 Lutetium
89 Ac 227 Actinium	90 Th 232.0377 Thorium	91 Pa 231.03588 Protactinium	92 U 238.02891 Uranium	93 Np 237 Neptunium	94 Pu 244 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 266 Lawrencium

Lanthanide Series

Actinide Series

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مركز القياس والتقويم التربوي
The Center for Educational Assessment
and Measurement (CEAM)



سَلْطَنَةُ عَمَانَ
وَزَارَةُ التَّوَسُّلِ وَالتَّجْلِيلِ

امتحان دبلوم التعليم العام للمدارس الخاصة (ثنائية اللغة) للعام الدراسي ١٤٤٢ هـ - ٢٠٢٠ / ٢٠٢١ م الدور الأول

- زمن الإجابة: ثلاث ساعات.
- الإجابة في الورقة نفسها.

- تنبيه: المادة: الكيمياء.
- الأسئلة في (١٤) صفحة.

تعليمات مهمة:

- يجب على الممتحن التأكد من استلام دفتر امتحانه، مغلفاً بغلاف بلاستيكي شفاف وغير ممزق، وهو مسؤول عنه حتى يسلمه لمراقبي اللجنة بعد الانتهاء من الإجابة.
- يجب الالتزام بضوابط إدارة امتحانات دبلوم التعليم العام وما في مستواه وأية مخالفة لهذه الضوابط تعرضك للتدابير والإجراءات والعقوبات المنصوص عليها بالقرار الوزاري رقم ٥٨٨ / ٢٠١٥.
- يقوم المتقدم بالإجابة عن أسئلة الامتحان المقالية بقلم الحبر (الأزرق أو الأسود).
- يقوم المتقدم بالإجابة عن أسئلة الاختيار من متعدد بتظليل الشكل (□) وفق النموذج الآتي:
س - عاصمة سلطنة عمان هي:
□ القاهرة □ الدوحة
■ مسقط □ أبوظبي
- ملاحظة: يتم تظليل الشكل (■) باستخدام القلم الرصاص وعند الخطأ، امسح بعناية لإجراء التغيير.
- يجب على الممتحن اصطحب الهواتف النقالة وأجهزة النداء الآلي وألات التصوير والحواسيب الشخصية والساعات الرقمية الذكية والآلات الحاسبة ذات الذاكرة التخزينية والمجلات والصحف والكتب الدراسية والدفاتر والمذكرات والحقائب اليدوية والآلات الحادة أو الأسلحة أياً كان نوعها وأي شيء له علاقة بالامتحان.
- يجب على الممتحن الامتثال لإجراءات التفطيش داخل المركز طوال أيام الامتحان.

صحيح ■ غير صحيح □



مُسَوِّدَةٌ، لَا يَتَمُّ تَصْحِيحُهَا

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Question 1: Multiple Choice Items**(12 marks)**

There are 12 multiple-choice items worth one mark each.

Shade in the bubble () next to the **correct** answer for each of the following items.

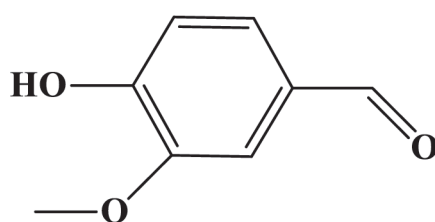
1) Which of the following about complex compounds is not correct?

- Ligands are the surrounding molecules to the central metal.
- Transition elements have variable oxidation states and form complex ions.
- The ions of all the 3d-block elements form complex ions by donating electrons.
- The co-ordination number of a complex is the number of dative bonds to the central metal ion.

2) What are the highest oxidation states for zinc and manganese in their complexes?

	Zinc	Manganese
<input type="radio"/>	+3	+3
<input type="radio"/>	+ 2	+7
<input type="radio"/>	+3	+6
<input type="radio"/>	+2	+2

3) Which of the following statements is not correct about the compound below?

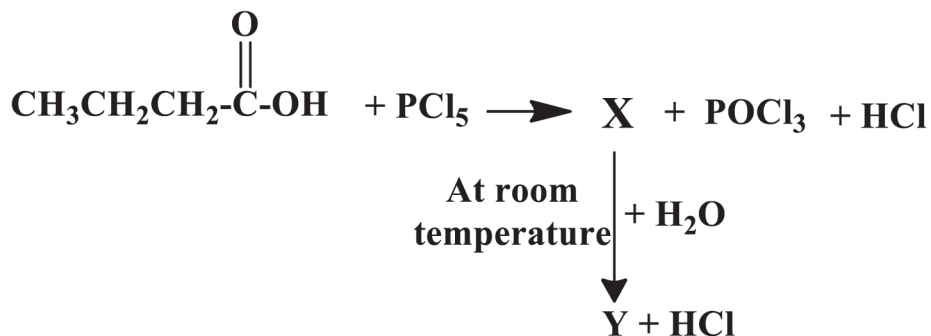


- It is an example of Arenes.
- This compound has a pleasant aroma.
- It shows the typical reactions of alkenes.
- The characteristic of its reaction is electrophilic substitution.

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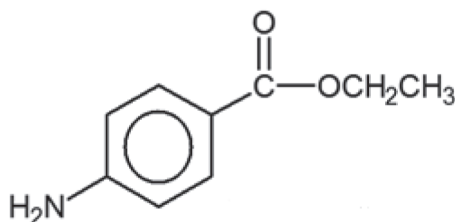
Question 1 continued

4) What is the correct option for the following reactions?



	X	Type of Y
<input type="radio"/>	$\text{CH}_3\text{CH}_2\text{COOCH}_3$	Alcohol
<input type="radio"/>	$\text{CH}_3\text{CH}_2\text{COOCH}_3$	Carboxylic acid
<input type="radio"/>	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COCl}$	Alcohol
<input type="radio"/>	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COCl}$	Carboxylic acid

5) What is the type of nitrogen functional group in the benzocaine compound shown below?



- Amine
 Amide
 Nitrile
 Amino acid

6) Which of the following pairs of compounds could form an amide with five carbons?

- $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$ with NH_3
 $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ with $\text{CH}_3\text{CH}_2\text{NH}_2$
 $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCl}$ with NH_3
 $\text{CH}_3\text{CH}_2\text{COCl}$ with $\text{CH}_3\text{CH}_2\text{NH}_2$

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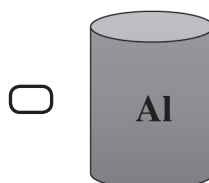
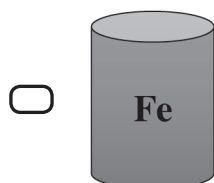
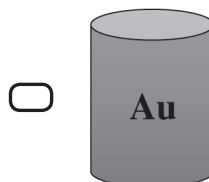
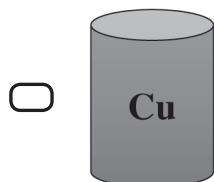
Question 1 continued

10) Which of the following statements describes the redox reaction correctly?

- The oxidizing agent loses electrons.
- The reducing agent undergoes oxidation.
- The oxidation number increases in reduction.
- The reduction reaction needs an oxidising agent.

11) Which of the following container could be used to preserve a solution of silver sulfate ($\text{Ag}_2\text{SO}_4(\text{aq})$)?

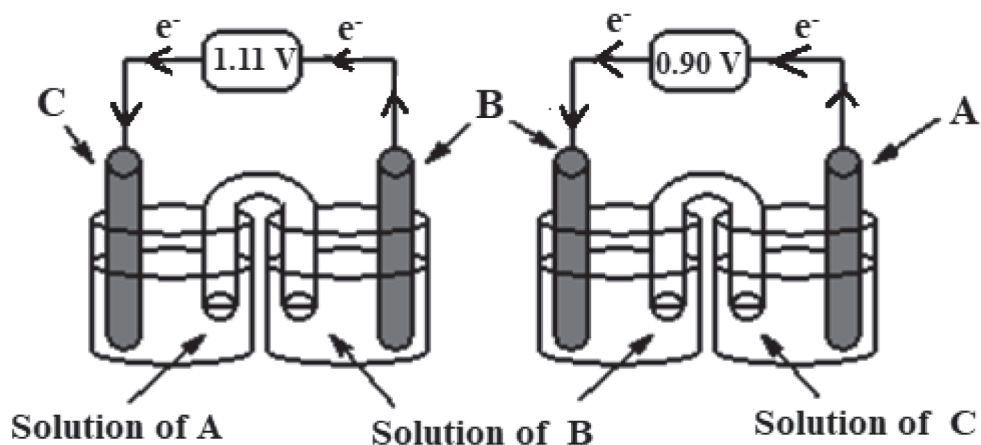
Half cell	E^\ominus/V
$\text{Fe}^{2+}_{(\text{aq})} \text{Fe}_{(\text{s})}$	-0.44
$\text{Cu}^{2+}_{(\text{aq})} \text{Cu}_{(\text{s})}$	+0.34
$\text{Ag}^+_{(\text{aq})} \text{Ag}_{(\text{s})}$	+0.80
$\text{Al}^{3+}_{(\text{aq})} \text{Al}_{(\text{s})}$	-1.66
$\text{Au}^{3+}_{(\text{aq})} \text{Au}_{(\text{s})}$	+1.50



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Question 1 continued

12) The diagram below shows two electrochemical cells:



The correct sequence for increasing reducing agent is:

- C > B > A
- B > A > C
- A > B > C
- A > C > B

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Question 2: Extended response**(48 marks)**

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Write your answer for each of the following questions in the space provided.
Be sure to show all your work, including the correct units where applicable.

13) Study the following table, then answer the questions below:

A	B	C
$[\text{Fe}(\text{CN})_6]^{4-}$	$[\text{Mn}(\text{OX})_3]^{3-}$	$[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$

a. What is the oxidation number of the transition metal in (A)?

b. What is the type of the ligand in complex ion B?

Monodentate

Bidentate

(shade your answer)

Explain your answer

c. When complex ion (C) reacts with 4 moles of concentrated hydrochloric acid it forms new complex ion and two molecules of water.

(i) Draw the shape of the new complex ion produced. Your drawing should clearly show three-dimensional shape and should include the overall charge on the complex ion.

(ii) What is the colour of the product.

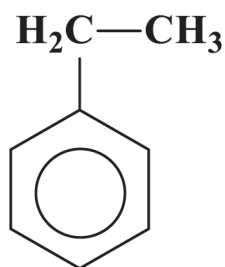
(iii) How many dative bonds in complex ion (C)?

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Question 2 continued

14) From your study about arenes answer the following questions.

a. Name the following compound according to IUPAC system:



b. Draw the structural formula of 2,5-dichlorophenol.

c. State the two reagents that are used in the acylation reaction of benzene.

d. Write the equation when phenol dissolved in an aqueous solution with pH more than 7?

15) Use the compounds in the table to answer the questions below:

A Benzoylchloride	B pentanoylchloride	C Chloropentane
D Phenol	E ethanoylChloride	F Ammonia

a. Write is the structural formula of the organic compound that will be produced from the reaction between compound (A) and compound (F).

b. Explain why the hydrolysis of compound (B) is easier than compound (C).

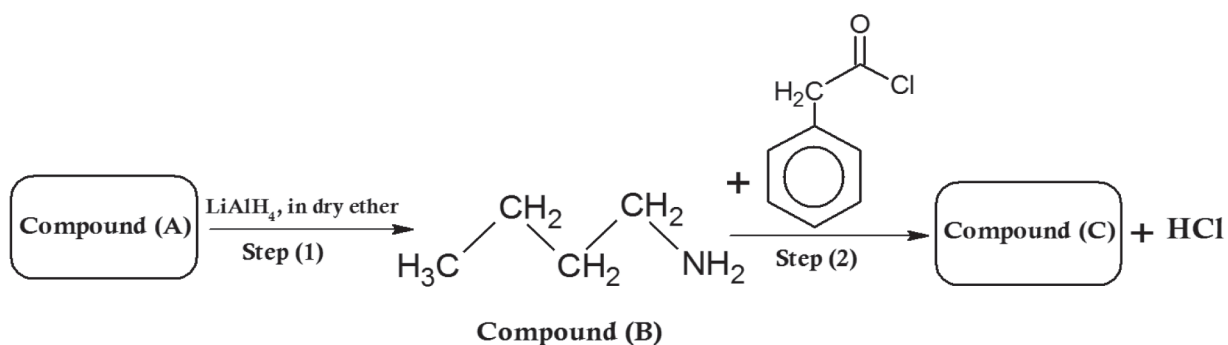
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Question 2 continued

c. What is the type of the reaction between compound (D) and (E)?

d. When compound (A) reacts with compound (F). What is the type of the organic product produced?

16) a. Study the following reaction sequence, then answer the following questions.

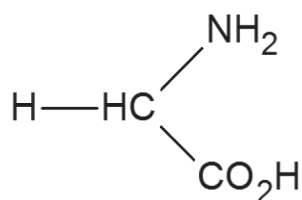


(i) Compound (A) is a nitrile. Draw its structural formula?

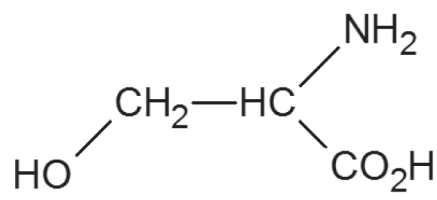
(ii) Name compound (B).

(iii) Draw the structural formula of compound (C).

b. The amino acids are the buildings blocks of proteins. The structures of two amino acids are shown below.



Glycine, Gly



Serine, Ser

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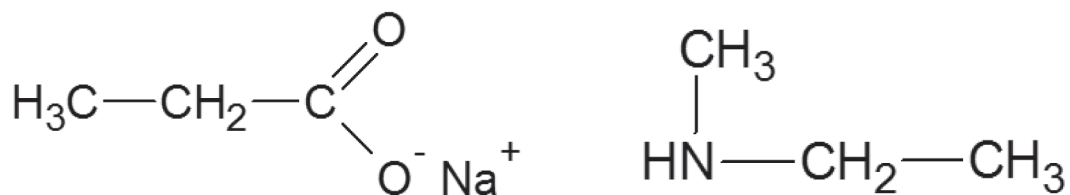
Question 2 continued

(i) What is the type of reaction of amino acids undergo to form proteins?

(ii) Draw the structural formula for the zwitterion of glycine.

(iii) Draw the structural formula of the dipeptide Gly-Ser. Label the peptide bond on your structure.

c. Compound (X), is a nitrogen compound hydrolysed under certain condition to form the following two compounds:



(i) What is the reagent and condition used in this reaction?

(ii) Draw the structural formula of compound (X).

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Question 2 continued

- 17) Propane $C_3H_{8(g)}$ combust in $O_{2(g)}$ under standard conditions according to the equation below. Use the data shown in the table to answer the following questions.



$$\Delta H_f^\theta [C_3H_{8(g)}] = -286 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\theta [CO_{2(g)}] = -393 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\theta [H_2O_{(l)}] = -286 \text{ kJ mol}^{-1}$$

- a. State Hess's law.

- b. Construct the enthalpy cycle then calculate the standard enthalpy change (the standard enthalpy changes of combustion), ΔH_c^θ , for the above reaction. Show all your calculations.

- c. Explain why this reaction is exothermic.

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Question 2 continued

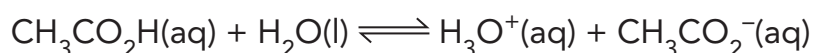
18) What is meant by the term half-life of the reaction?

19) a. K_w is called the ionic product of water.

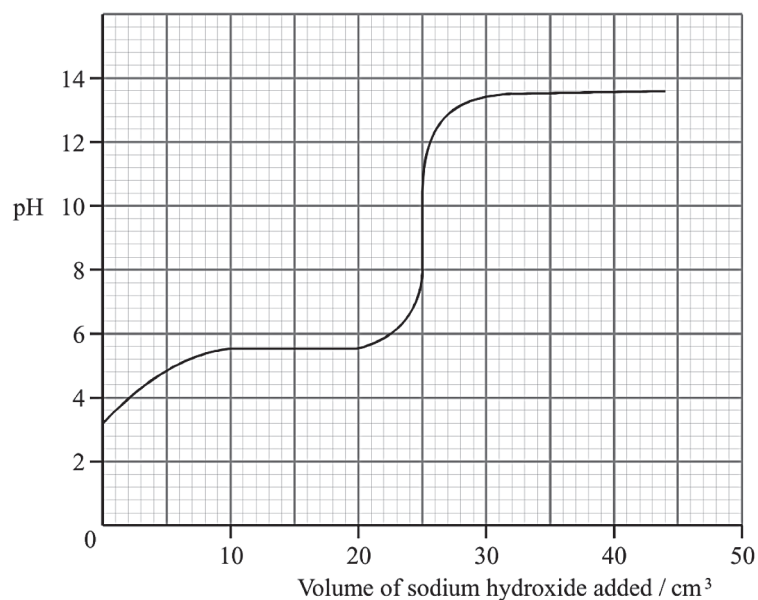
(i) Write the general expression for K_w .

(ii) What is the factor that affects the value of K_w ?

b. Ethanoic acid, dissociates in water according to the equation:



25 cm³ of 0.06 mol dm⁻³ aqueous ethanoic acid, was titrated with 0.06 mol dm⁻³ aqueous sodium hydroxide and the pH measured throughout. The titration curve is shown below.



(i) Write an expression for the dissociation constant, K_a , for ethanoic acid.

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Question 2 continued

Use the titration curve to find:

(ii) The value of the pH at the end point of the titration.

(iii) The value of K_a for the ethanoic acid. (pH for the ethanoic acid = 3)

c. Which indicator is suitable for this titration: methyl orange pH range (3.2-4.4) or phenolphthalein pH range (8.2-10).

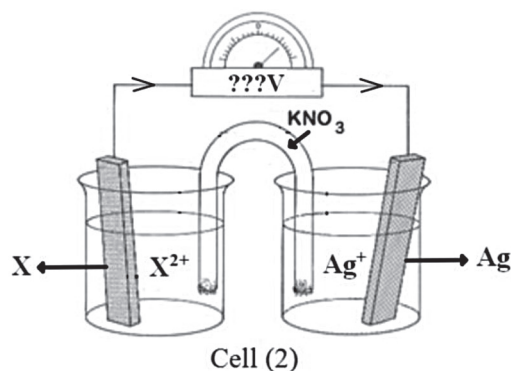
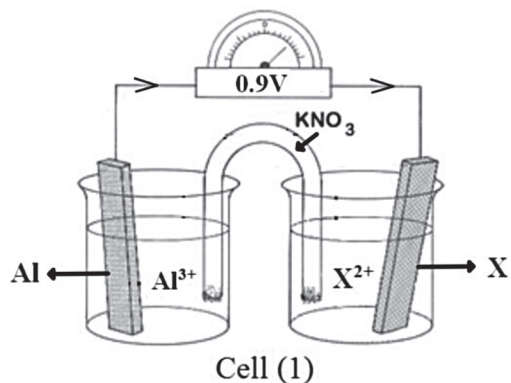
d. A solution containing $H_2CO_3(aq)$ and $NaHCO_3(aq)$ acts as a buffer solution.

(i) What is meant by the buffer solution?

(ii) Explain with equations how this mixture acts as a buffer when a few drops of strong acid are added.

Question 2 continued

- 20) Study the table below and the two electrochemical cell diagrams under standard conditions to answer the following questions. Cell (1) consists of (Al) electrode and unknown electrode represented by (X). Cell (2) consists of (Ag) electrode and the same unknown electrode represented by (X).



Half -cell	E^θ/V
$Al^{3+}_{(aq)} Al_{(s)}$	-1.66
$Ag^+_{(aq)} Ag_{(s)}$	+0.80

- a. What are the standard conditions of temperature and concentration of solutions?

- b. What is the purpose of the salt bridge in the cells?

- c. For cell (1):

- (i) Which one is the anode electrode in cell (1)?

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Question 2 continued

- (ii) Write the cell diagram as a short-hand way to represent the reactions that occur in cell (1)?

- (iii) Write the balanced equation for the overall cell reaction for cell (1)?

- d. For cell (2):

- (i) Write the half-cell oxidation and reduction reactions that occur in cell (2).

The half-cell oxidation reaction: _____

The half-cell reduction reaction: _____

- (ii) Calculate the standard electromotive force (E_{cell}^{θ}) for cell (2)?

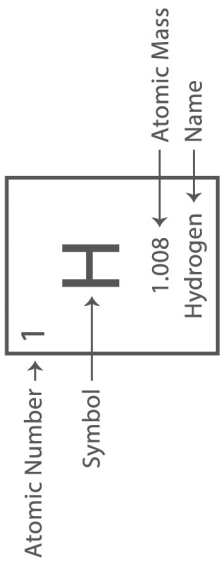
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PERIODIC TABLE OF THE ELEMENTS

1 H 1.008 Hydrogen	2 He 4.002602 Helium	3 Li 6.94 Lithium	4 Be 9.0121831 Beryllium	5 B 10.81 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998403163 Fluorine	10 Ne 20.1797 Neon	11 Na 22.98976928 Sodium	12 Mg 24.305 Magnesium	13 Al 26.9815385 Aluminium	14 Si 28.085 Silicon	15 P 30.973761998 Phosphorus	16 S 32.06 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.948 Argon	19 K 39.0983 Potassium	20 Ca 40.078 Calcium	21 Sc 44.955908 Scandium	22 Ti 47.867 Titanium	23 V 50.9415 Vanadium	24 Cr 51.9961 Chromium	25 Mn 54.938044 Manganese	26 Fe 55.845 Iron	27 Co 58.933194 Cobalt	28 Ni 58.6934 Nickel	29 Cu 63.546 Copper	30 Zn 65.38 Zinc	31 Ga 69.723 Gallium	32 Ge 72.630 Germanium	33 As 74.921595 Arsenic	34 Se 78.971 Selenium	35 Br 79.904 Bromine	36 Kr 83.798 Krypton	37 Rb 85.4678 Rubidium	38 Sr 87.62 Strontium	39 Y 88.90584 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.90637 Niobium	42 Mo 95.95 Molybdenum	43 Tc 98 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.90550 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.8682 Silver	48 Cd 112.414 Cadmium	49 In 114.818 Indium	50 Sn 118.710 Tin	51 Sb 121.760 Antimony	52 Te 127.60 Tellurium	53 I 126.90447 Iodine	54 Xe 131.293 Xenon	55 Cs 132.90545196 Caesium	56 Ba 137.327 Barium	57 La 138.90547 Lanthanum	58 Ce 140.116 Cerium	59 Pr 140.90766 Praseodymium	60 Nd 144.242 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92535 Terbium	66 Dy 162.500 Dysprosium	67 Ho 164.93033 Holmium	68 Er 167.259 Erbium	69 Tm 168.93422 Thulium	70 Yb 173.054 Ytterbium	71 Lu 174.9668 Lutetium	72 Hf 178.49 Hafnium	73 Ta 180.94788 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.217 Iridium	78 Pt 195.084 Platinum	79 Au 196.966569 Gold	80 Hg 200.592 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98040 Bismuth	84 Po 209 Polonium	85 At 210 Astatine	86 Rn 222 Radon	87 Fr 223 Francium	88 Ra 226 Radium	89 Ac 227 Actinium	90 Th 232.0377 Thorium	91 Pa 231.03588 Protactinium	92 U 238.02891 Uranium	93 Np 237 Neptunium	94 Pu 244 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 266 Lawrencium	104 Rf 267 Rutherfordium	105 Sg 269 Seaborgium	106 Db 268 Dubnium	107 Bh 270 Bohrium	108 Hs 269 Hassium	109 Mt 278 Meitnerium	110 Ds 281 Darmstadtium	111 Rg 281 Roentgenium	112 Cn 285 Copernicium	113 Uut 286 Ununtrium	114 Fl 289 Flerovium	115 Uup 289 Ununpentium	116 Lv 293 Livermorium	117 Uus 294 Ununseptium	118 Uuo 294 Ununoctium
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مركز القياس والتقويم التربوي
The Center for Educational Assessment
and Measurement (CEAM)



سَلْطَنَةُ عَمَانَ
وَزَارَةُ التَّوْبِيَةِ وَالتَّعْلِيمِ

امتحان دبلوم التعليم العام للمدارس الخاصة (ثنائية اللغة) للعام الدراسي ١٤٤٢ هـ - ٢٠٢٠ / ٢٠٢١ م الدور الثاني

- زمن الإجابة: ثلاث ساعات.
- الإجابة في الورقة نفسها.

- تنبيه: المادة: الكيمياء.
- الأسئلة في (١٢) صفحة.

تعليمات مهمة:

- يجب على الممتحن التأكد من استلام دفتر امتحانه، مغلفاً بغلاف بلاستيكي شفاف وغير ممزق، وهو مسؤول عنه حتى يسلمه لمراقبي اللجنة بعد الانتهاء من الإجابة.
- يجب الالتزام بضوابط إدارة امتحانات دبلوم التعليم العام وما في مستواه وأية مخالفة لهذه الضوابط تعرضك للتدابير والإجراءات والعقوبات المنصوص عليها بالقرار الوزاري رقم ٥٨٨ / ٢٠١٥.
- يقوم المتقدم بالإجابة عن أسئلة الامتحان المقالية بقلم الحبر (الأزرق أو الأسود).
- يقوم المتقدم بالإجابة عن أسئلة الاختيار من متعدد بتظليل الشكل (□) وفق النموذج الآتي:
س - عاصمة سلطنة عمان هي:
□ القاهرة □ الدوحة
■ مسقط □ أبوظبي
- ملاحظة: يتم تظليل الشكل (■) باستخدام القلم الرصاص وعند الخطأ، امسح بعناية لإجراء التغيير.
- يجب على الممتحن اصطحب الهواتف النقالة وأجهزة النداء الآلي وألات التصوير والحواسيب الشخصية والساعات الرقمية الذكية والآلات الحاسبة ذات الذاكرة التخزينية والمجلات والصحف والكتب الدراسية والدفاتر والمذكرات والحقائب اليدوية والآلات الحادة أو الأسلحة أياً كان نوعها وأي شيء له علاقة بالامتحان.
- يجب على الممتحن الامتنال لإجراءات التفطيش داخل المركز طوال أيام الامتحان.

صحيح ■ غير صحيح □



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Question 1: Multiple Choice Items**(12 marks)**

There are 12 multiple-choice items worth one mark each.
Shade in the bubble () next to the **correct** answer for each of the following items.

- 1) Which of the following compounds contains a bidentate ligand:
- $[\text{Fe}(\text{CN})_6]^{3-}$
 - $[\text{Mg}(\text{H}_2\text{O})_6]^{2+}$
 - $[\text{Ag}(\text{NH}_3)_2]^{1+}$
 - $[\text{Co}(\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2)]^{2+}$
- 2) What is the shape of the complex ion $[\text{Fe}(\text{SCN})(\text{H}_2\text{O})_5]^{2+}$
- Octahedral
 - Tetrahedral
 - Square planar
 - Linear
- 3) Which of these catalysts is important to form phenylethane from benzene with chloroethane:
- Concentrated H_2SO_4 with heat.
 - Aluminum chloride with heat.
 - Anhydrous iron (III) bromide.
 - Potassium dichromate.
- 4) The reaction between acylchloride and alcohol will give:
- phenols
 - esters
 - amides
 - ketones

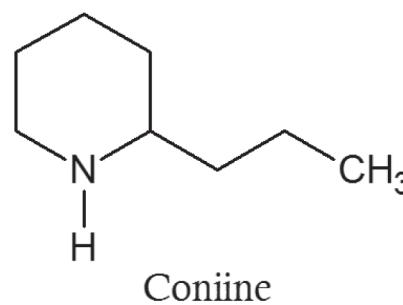
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Question 1 continued

5) Coniine is a poisonous chemical compound:

What is the functional group in coniine?

- Amine
- Amide
- Nitrile
- Amino acid



6) Which of the following reactants could be used to produce butanamide, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CONH}_2$?

- $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$ and NH_3
- $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCl}$ and NH_3
- $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$ and CH_3NH_3
- $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCl}$ and CH_3NH_3

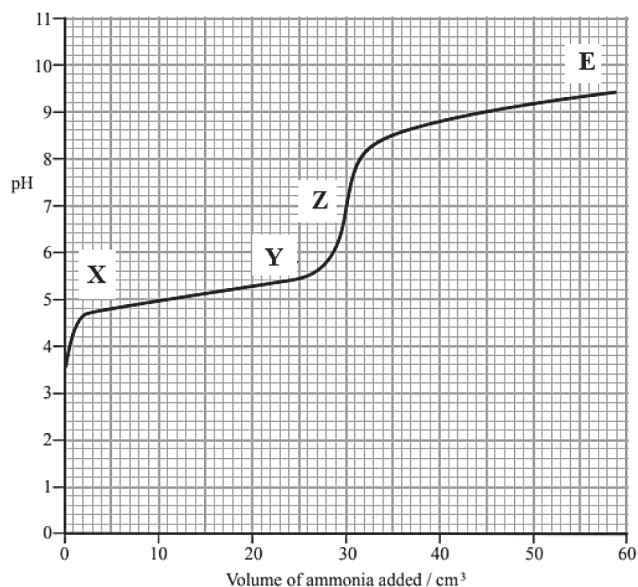
7) Sodium hydroxide solution was added to hydrochloric acid in a polystyrene cup and the initial temperature of both of them were 18°C and the final temperature of the mixture was 31°C .

Which of the following is correct about this reaction?

- This reaction is endothermic.
- The heat is given out to the surrounding.
- The enthalpy change (ΔH) for this reaction is positive.
- This reaction is used to find the enthalpy change (ΔH) of solution.

Question 1 continued

Study the following titration curve to answer questions (8 and 9):



8) What is the type of this titration?

- Strong acid with strong alkali
- Strong acid with weak alkali
- Weak acid with strong alkali
- Weak acid with weak alkali

9) Which of the following represent the equivalence point?

- X
- Y
- Z
- E

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Question 1 continued

10) Which of the following statements is correct about the electrochemical cell?

- The $E^{\ominus}_{\text{cell}}$ is always negative.
- The reducing agent undergoes oxidation.
- The cathode is always the negative electrode.
- The voltage produced by it is independent on the conditions.

Study the following table to answer questions (11 and 12):

Half cell	E^{\ominus}/V
$\text{Zn}^{2+}_{(\text{aq})} \text{Zn}_{(\text{s})}$	-0.76
$\text{Ag}^{+}_{(\text{aq})} \text{Ag}_{(\text{s})}$	+0.80
$\text{Cu}^{2+}_{(\text{aq})} \text{Cu}_{(\text{s})}$	+0.34
$\text{Fe}^{2+}_{(\text{aq})} \text{Fe}_{(\text{s})}$	-0.44
$\text{Al}^{3+}_{(\text{aq})} \text{Al}_{(\text{s})}$	-1.66

11) The table above shows the standard electrode potentials (E^{\ominus}/V) for five half-reactions cells. Which of the following metals is the strongest reducing agent?

- $\text{Zn}_{(\text{s})}$
- $\text{Fe}_{(\text{s})}$
- $\text{Ag}_{(\text{s})}$
- $\text{Al}_{(\text{s})}$

12) Which two metals from the table can be used to construct an electrochemical cell with the largest electromotive force ($E^{\ominus}_{\text{cell}}$):

- Ag, Cu
- Ag, Al
- Al, Fe
- Ag, Fe

Question 2: Extended response**(48 marks)**

Write your answer for each of the following questions in the space provided.
Be sure to show all your work, including the correct units where applicable.

13) When the complex ion hexaaquairon (III) reacts with 3 moles of sodium hydroxide, a precipitate will be formed.

a. What is the meaning of the term complex ion?

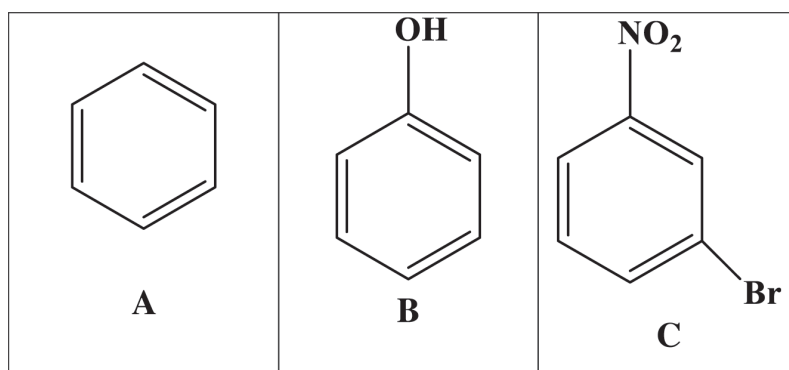
b. What is the colour of the precipitate?

c. Write the equation for this reaction?

14) Complete the following table about the complex ion $[\text{Cr}(\text{OH})_6]^{3-}$

Number of dative bonds	The oxidation state of the central metal
_____	_____

Study the arenes in the table below to answer questions 15 and 16.



15) a. Name the compound (C).

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Question 2 continued

- b. When a mixture of concentrated nitric acid and concentrated sulfuric acid are added to compound (B) 2, 4, 6-trinitrophenol will be produced. Draw the structure of the product.

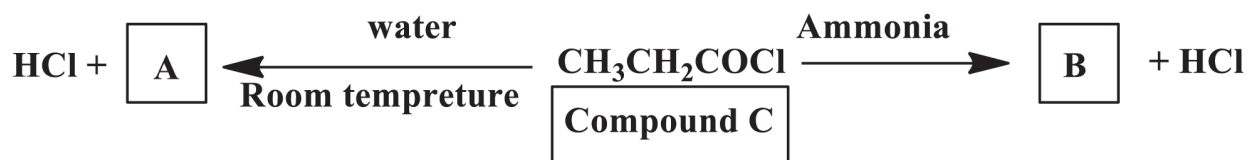
- 16) For the compound (A) shown in the above table.

- a. How much the bond angles in compound (A).

- b. Explain why the C-C bonds in compound (A) have the same length?

- c. Draw the structural formula of the product when compound (A) reacts with 3 moles of $H_2(g)$.

- 17) Study the diagram below, then answer the following questions.



- a. Draw the structural formula of the organic compound (A)?

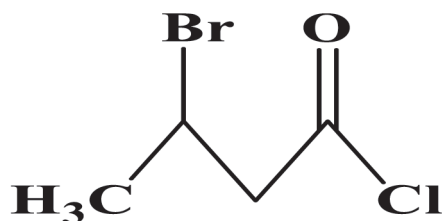
- b. What is the type of the reaction that will produce compound (B)?

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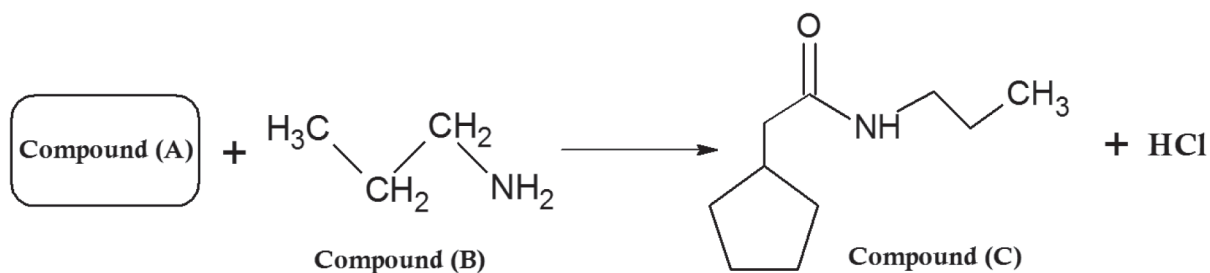
Question 2 continued

- c. Write the equation for the reaction which shows the formation of the compound (C) from the compound (A)?

- d. Name the following compound.



- 18) a. Study the following reaction, then answer the following questions:



- (i) Draw the structural formula of compound (A).

- (ii) Name compound (B).

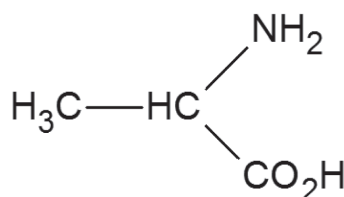
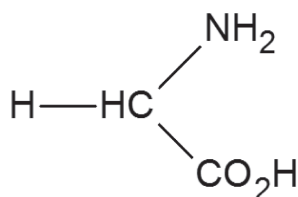
- (iii) Write a reaction equation for the reduction of compound (C).

- (iv) What are the products for the hydrolysis of compound (C) carried out with heat in dilute $\text{H}_2\text{SO}_{4(aq)}$.

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Question 2 continued

b. Consider the following two compounds, to answer the following questions:



(i) What is the class of these compounds?

These two compounds undergo condensation reaction between themselves to form compound (X).

(ii) What is compound (X) called?

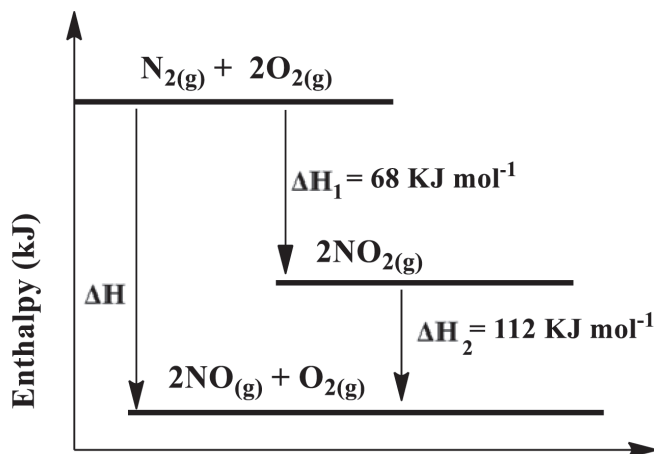
(iii) Draw the structural formula of compound (X).

19) $\text{N}_{2(\text{g})}$ reacts with $\text{O}_{2(\text{g})}$ under standard conditions according to the equation below. Use the data in the table and the enthalpy level diagram shown to answer the following questions.



$\Delta H_f^\ominus [\text{NO}_{(\text{g})}] = +90 \text{ kJ mol}^{-1}$

$\Delta H_f^\ominus [\text{NO}_{2(\text{g})}] = +34 \text{ kJ mol}^{-1}$
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Question 2 continued

- a. How much the standard enthalpy of formation (ΔH_f^\ominus) of $O_{2(g)}$ under standard conditions.

- b. Construct the enthalpy cycle then calculate the standard enthalpy change of reaction for this reaction. Show all your calculations.

- c. Is this an exothermic or endothermic reaction? Explain your answer.

- 20) Define the term rate of reaction.

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Question 2 continued

21) a. The buffer solution plays an important role in nature and in many industrial processes.

(i) What is meant by the term buffer solution?

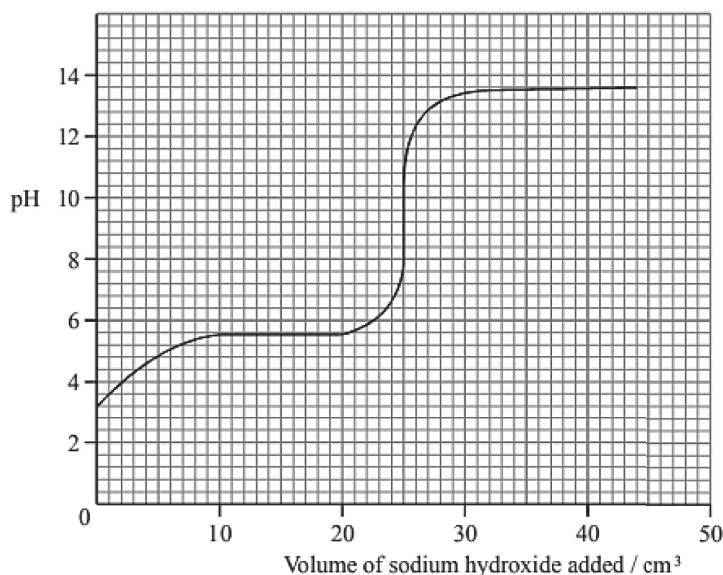
(ii) What are the components of the buffer solution?

b. 25 cm³ of 0.05 mol dm⁻³ aqueous HA_(aq) its $K_a = 6.3 \times 10^{-5}$ mol dm⁻³.

(i) Write an expression for the dissociation constant, K_a , for HA.

(ii) Calculate the value of pH for this acid.

c. Study the titration curve shown below. Then answer the following questions.



(i) What is the value of the pH at the end point of the titration?

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Question 2 continued

(ii) What is the pH value where the best buffering action occurs during this titration?

(iii) Which indicator is suitable methyl orange pH range (3.2 - 4.4) or phenolphthalein pH range (8.2 - 10) would be the better to use for this titration. Explain your answer.

The suitable indicator _____

The explanation _____

22) A student investigated the reactions of three different metals (magnesium, iron and zinc) with their aqueous sulfate solutions to determine their cell potentials, $E^{\ominus}_{\text{cell}}$, for the three electrochemical cells below at standard conditions.

Reaction	Cell reaction
1	$\text{Mg(s)} + \text{Cu}^{2+}(\text{aq}) \longrightarrow \text{Mg}^{2+}(\text{aq}) + \text{Cu(s)}$
2	$\text{Zn(s)} + \text{Cu}^{2+}(\text{aq}) \longrightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu(s)}$
3	$\text{Fe(s)} + \text{Cu}^{2+}(\text{aq}) \longrightarrow \text{Fe}^{2+}(\text{aq}) + \text{Cu(s)}$

a. What is the name of the part in these cells that is used to allow ions to flow and maintain them?

b. From which electrode (positive or negative) to which electrode (positive or negative) the electrons flow?

c. How can you predict if a reaction will occur or not?

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Question 2 continued

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- d. Write the cell diagram for the magnesium/copper cell.

- e. Which electrode is the anode in the zinc/copper cell consisting of $\text{Zn}^{2+}(\text{aq})/\text{Zn}(\text{s})$ half-cell and $\text{Cu}^{2+}(\text{aq})/\text{Cu}(\text{s})$ half-cell?

- f. Draw a fully labelled diagram for the electrochemical cell for the iron/copper cell to show how the apparatus should be set up to measure the cell potential, $E_{\text{cell}}^{\ominus}$. Your labels should include the names of the metals, parts, the names and concentrations of the solutions you would use.

- g. If the $\text{Cu}^{2+}(\text{aq})$ in reaction (2) is replaced with $\text{Mn}^{2+}(\text{aq})$ to be



Predict whether this reaction is feasible or not. Prove your answer by calculations.

Half-cell	E^{\ominus}/V
$\text{Zn}^{2+}(\text{aq})/\text{Zn}(\text{s})$	-0.76
$\text{Mn}^{2+}(\text{aq})/\text{Mn}(\text{s})$	-1.18

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