



CHEMISTRY

Paper 1 Multiple Choice

9729/01

18 September 2024

1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, civics group and registration number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this question paper.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **12** printed pages.

- 1 A gravimetric analysis of a sample of an iron ore was carried out.

0.6 g of ore was dissolved in perchloric acid to oxidise the iron to Fe^{3+} . The resultant solution was filtered to remove solid impurities and made basic to precipitate the Fe^{3+} as the hydroxide. The precipitate was filtered and heated to produce 0.32 g of Fe_2O_3 .

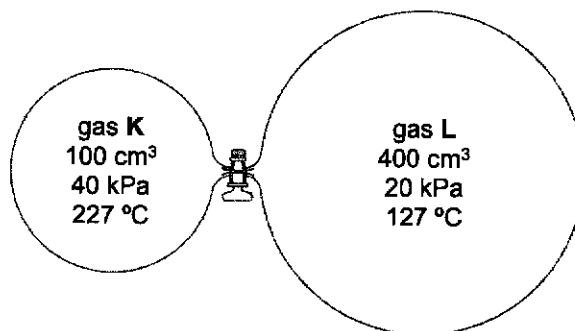
What is the percentage by mass of iron in the ore?

- A** 18.6% **B** 37.3% **C** 53.0% **D** 69.9%
- 2 Ions of element Y can exist in variable oxidation states. 25.0 cm^3 of $0.400 \text{ mol dm}^{-3} \text{ Y}^{2+}$ solution requires 40.00 cm^3 of $0.100 \text{ mol dm}^{-3}$ acidified KMnO_4 for a complete reaction.
- What is the final oxidation state of Y?
- A** +4 **B** +3 **C** 0 **D** -1
- 3 Which of the following ions would experience the greatest angle of deflection in its path when passing through the same electric field?
- A** $^{24}\text{Mg}^+$ **B** $^{48}\text{Ti}^{3+}$ **C** $^{59}\text{Co}^{2+}$ **D** $^{101}\text{Ru}^{4+}$

- 4 Which of the following shows the correct shape and bond angle of the molecule given?

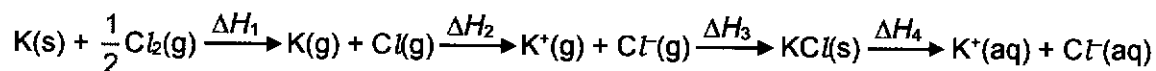
	molecule	shape	bond angle
A	OF_2	bent	117°
B	BF_3	trigonal pyramidal	120°
C	XeF_4	tetrahedral	109.5°
D	SF_6	octahedral	90°

- 5 Ideal gases K and L, initially at different pressures and temperatures, are placed in different bulbs that are connected by a narrow tube of negligible volume as shown.



When the tap is opened, the gases mix. What is the final pressure of the mixture if both bulbs are maintained at 227 °C?

- A 28.0 kPa B 30.0 kPa C 36.6 kPa D 68.6 kPa
- 6 The enthalpy changes involved in the formation of $\text{KCl}(\text{aq})$ from $\text{K}(\text{s})$ and $\text{Cl}_2(\text{g})$ are as follows:



Which of the following statements are correct?

- 1 The lattice energy of potassium chloride is ΔH_3 .
- 2 The enthalpy change of solution of potassium chloride is $(\Delta H_3 + \Delta H_4)$.
- 3 The enthalpy change of formation of solid potassium chloride is $(\Delta H_1 + \Delta H_2 + \Delta H_3)$.

- A 1 only B 1 and 3 only C 2 and 3 only D 1, 2 and 3

- 7 In this question, the symbol '<' means 'less positive than' or 'more negative than'.

Silver chloride dissolves in dilute $\text{NH}_3(\text{aq})$ whereas silver bromide is only soluble in concentrated $\text{NH}_3(\text{aq})$.

The following equations represent the equilibria involved.



Some relationships between the free energies of these four reactions are as follows.

1 $(\Delta G_1 + \Delta G_2) < (\Delta G_3 + \Delta G_4)$

2 $\Delta G_2 = \Delta G_4$

3 $\Delta G_2 < \Delta G_4$

4 $\Delta G_1 < \Delta G_3$

Which relationships are correct?

- A 1, 2 and 4 only B 1 and 3 only C 2 and 4 only D 3 only

- 8 Photochromic glass is used in transition lens. It quickly darkens when exposed to UV light and slowly becomes more transparent again when the intensity of UV light decreases. The depth of colour of the glass is proportional to the concentration of silver atoms present.

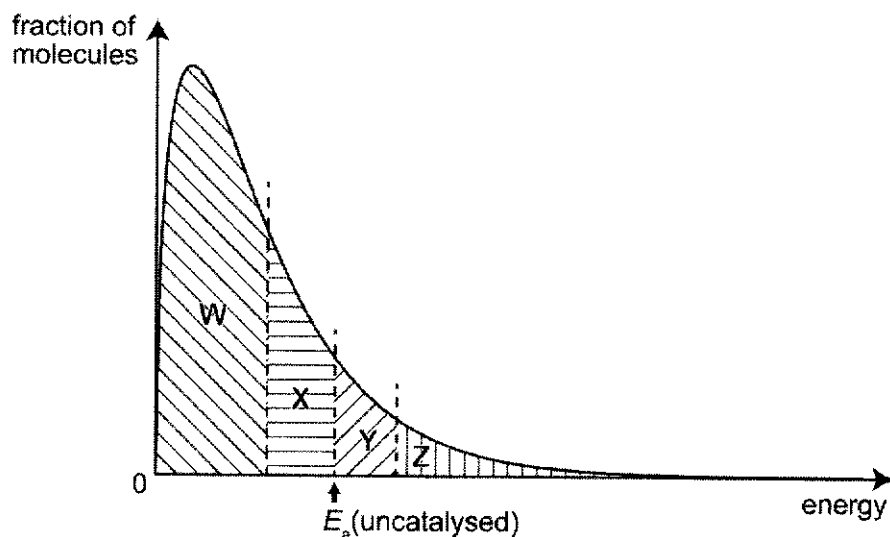
The following reactions are involved:



Which statement about these reactions is correct?

- A Since Cu^+ and Cu^{2+} acts as catalysts, both reactions 2 and 3 are much faster than the forward reaction in $\text{Ag}^+ + \text{Cl}^- \rightleftharpoons \text{Ag} + \text{Cl}$ when intensity of UV light is high.
- B The forward reaction in $\text{Ag}^+ + \text{Cl}^- \rightleftharpoons \text{Ag} + \text{Cl}$ is non-spontaneous.
- C Reaction 3 is less spontaneous after glass darkens in UV light, as compared to the glass being clear.
- D The position of equilibrium of reaction 1 shifts to the left in strong UV light.

- 9 The distribution of the number of molecules with energy E for an uncatalysed reaction with a given activation energy, E_a , is shown in the diagram below.



Which expression gives the fraction of the molecules that results in a reaction occurring when a catalyst is added at the start of the same reaction?

- A $\frac{X+Y+Z}{W}$ B $\frac{Z}{W+X+Y}$ C $\frac{X+Y+Z}{W+X+Y+Z}$ D $\frac{Z}{W+X+Y+Z}$

- 10 The K_c value of reaction 1 is 2.55×10^{65} at 373 K. Reaction 1 is catalysed by zirconium metal.



Which of the following statements regarding reaction 1 are true?

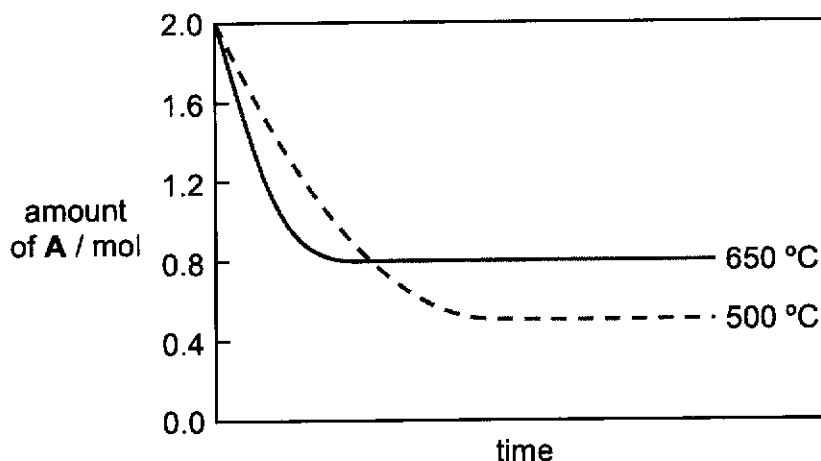
- 1 The forward reaction proceeds very quickly because the K_c value is very large.
- 2 The K_c value will increase when boiling water is added and the mixture is kept at 373 K and 1 atm.
- 3 After the addition of a few granules of zirconium, the K_c value remains at 2.55×10^{65} .

- A 3 only B 1 and 2 only C 2 and 3 only D 1, 2, and 3

- 11 Gas **A** decomposes to two other gases, **B** and **C**, according to the following equation:



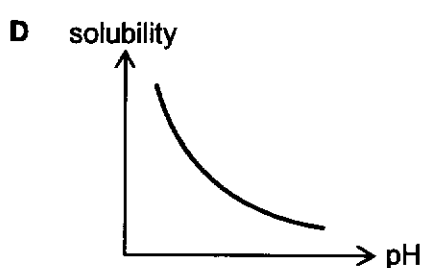
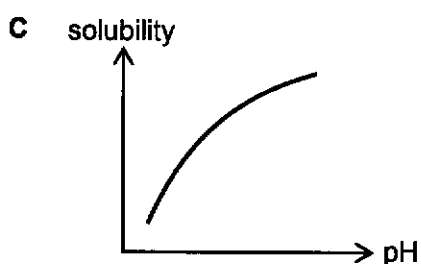
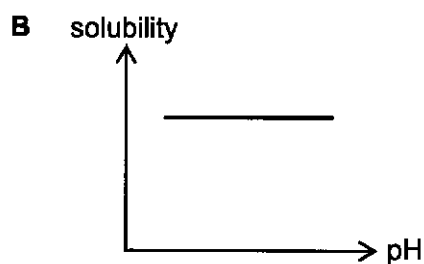
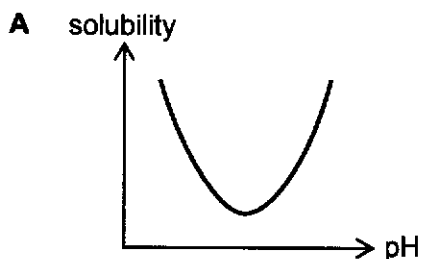
The graph shows the decomposition of 2.0 mol of pure gas **A** in the presence of a catalyst at various temperatures.



- Which one of the following statements about the above system is **correct**?
- A** The decomposition of **A** is endothermic.
B The K_p of the system decreases with increasing temperature.
C The percentage of **A** decomposed is 40% when equilibrium is reached at 650 °C.
D The amount of **C** at equilibrium is 0.8 mol at 650 °C.
- 12 What is the pH of the final solution formed when $V \text{ dm}^3$ of dilute hydrochloric acid of pH 2.0 is mixed with $V \text{ dm}^3$ of dilute sulfuric acid of pH 2.0, followed by the addition of $2V \text{ dm}^3$ of water?
- A** 1.33 **B** 2.00 **C** 2.30 **D** 4.00
- 13 A buffer solution consists of an aqueous solution of a weak acid and its sodium salt. Which of the following expressions gives the best estimate of the hydrogen ion concentration?
- A** $[\text{H}^+] = \sqrt{K_a [\text{acid}]}$ **B** $[\text{H}^+] = \sqrt{K_a [\text{salt}]}$
C $[\text{H}^+] = K_a \frac{[\text{acid}]}{[\text{salt}]}$ **D** $[\text{H}^+] = K_a \frac{[\text{salt}]}{[\text{acid}]}$

- 14 Calcium oxalate, CaC_2O_4 , is a sparingly soluble salt and is added to a weakly acidic solution of oxalic acid, $\text{H}_2\text{C}_2\text{O}_4$. The pH of the solution is adjusted by adding NaOH.

Which diagram shows how the solubility of CaC_2O_4 will vary with the pH of the solution at constant temperature?



- 15 Which property of the first six elements of Period 3 (sodium to sulfur) continuously increases in magnitude?

- A atomic radius
- B first ionisation energy
- C maximum oxidation number in oxide
- D melting point of the highest chloride

- 16 Gallstones can form in the gall bladder and are very painful. The inorganic part of gallstones is calcium oxalate, CaC_2O_4 , which is insoluble in water. The corresponding magnesium oxalate, MgC_2O_4 , is soluble in water.

What factor accounts for the difference in solubility between CaC_2O_4 and MgC_2O_4 ?

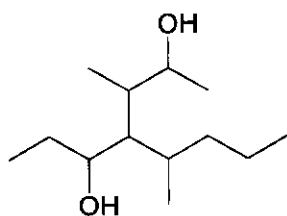
- A The entropy change for dissolution of MgC_2O_4 is more negative than CaC_2O_4 due to the higher charge density of Mg^{2+} .
- B Mg^{2+} ions have a more negative enthalpy change of hydration than Ca^{2+} ions.
- C MgC_2O_4 has a more negative lattice energy than CaC_2O_4 .
- D Mg is more electronegative than Ca.

17 Which statements about the Group 17 elements (X_2) from chlorine to iodine are correct?

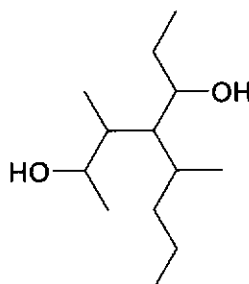
- 1 The bond energy of $X-X$ decreases down the group.
- 2 The volatility of the elements decreases down the group.
- 3 The elements become stronger oxidising agents down the group.

A 2 only B 1 and 2 only C 1 and 3 only D 1, 2 and 3

18 Consider compounds **R** and **S** below.



compound **R**

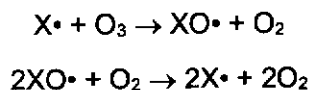


compound **S**

Which of the following statements regarding compounds **R** and **S** is correct?

- A Compound **R** can exist as a total of 16 stereoisomers.
 - B Compounds **R** and **S** are constitutional isomers of each other.
 - C At least one constitutional isomer of **S** cannot rotate polarised light.
 - D At least one stereoisomer of compound **R** cannot rotate plane polarised light.
- 19 When dichlorodifluoromethane, CCl_2F_2 , is released into the atmosphere, it accumulates in the upper part of the atmosphere where it reacts to form free radicals due to the action of ultraviolet light.

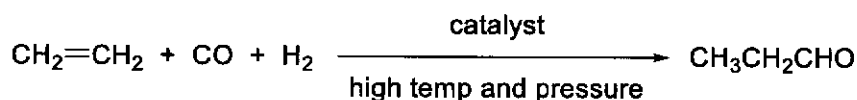
One of the chain reactions which can occur is shown, where $X\cdot$ represents the halogen radical.



Which statement is correct?

- A $F\cdot$ and $\cdot CCl_2F$ are the major free radical products made during the initiation step.
- B The halogen radical acts as a catalyst in the breakdown of ozone.
- C The halogen radical is formed during the termination step.
- D $F\cdot$ is produced, but unlike $Cl\cdot$, does not react with ozone.

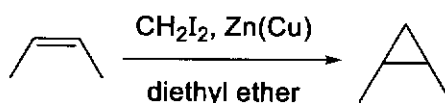
- 20 The oxo reaction is an important industrial process in which alkene combines directly with carbon monoxide and hydrogen under suitable conditions. The reaction with ethene is shown.



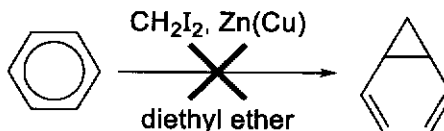
Which alkene undergoes the oxo reaction to give the product $\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)_2\text{CHO}$?



- 21 The Simmons-Smith reaction involves the formation of a cyclopropane ring from an alkene, using diiodomethane, a zinc-copper alloy, and diethyl ether as a solvent.



However, when the same reagents and conditions for the Simmons-Smith reaction are used on benzene, the cyclopropane ring is not formed.

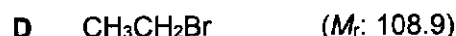
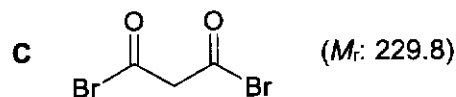
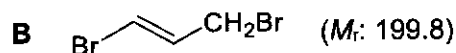
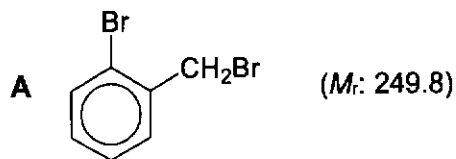


Which of the following statements best explains this phenomenon?

- A The alkene is a weaker nucleophile than benzene.
 B Forming the cyclopropane ring will destroy the stable aromatic structure of benzene.
 C The C=C double bond in an alkene is weaker, hence it is more reactive.
 D The benzene ring lacks a directing alkyl group required to cause the cyclopropane ring to form.
- 22 Which sequence shows the correct order of increasing ease of hydrolysis?
- A $\text{CH}_3\text{CH}_2\text{Cl} < \text{CH}_3\text{CH}_2\text{Br} < \text{CH}_3\text{CH}_2\text{I}$
 B $(\text{CH}_3)_2\text{CHCl} < (\text{CH}_3)_2\text{CHBr} < (\text{CH}_3)_2\text{CHF}$
 C $\text{C}_6\text{H}_5\text{CH}_2\text{I} < \text{C}_6\text{H}_5\text{CH}_2\text{Br} < \text{C}_6\text{H}_5\text{CH}_2\text{Cl}$
 D $\text{C}_6\text{H}_5\text{CH}_2\text{Cl} < \text{C}_6\text{H}_5\text{CH}_2\text{Br} < \text{C}_6\text{H}_5\text{I}$

- 23 One gram of each of the following compounds was heated with NaOH(aq), followed by addition of dilute HNO₃ and AgNO₃(aq).

Which compound will produce the largest mass of AgBr(s)?

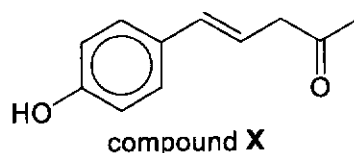


- 24 Alcohol X with molecular formula C₄H₁₀O is oxidised by acidified potassium dichromate(VI) solution and produces a pale yellow precipitate with alkaline aqueous iodine.

Which compound could be X?

- A 2-methylpropan-1-ol
 B 2-methylpropan-2-ol
 C butan-1-ol
 D butan-2-ol

- 25 The structure of compound X is shown:



Which of the following statements will be observed with compound X?

- 1 Compound X decolourises hot acidified potassium manganate(VII).
- 2 1 mole of yellow precipitate is formed when 1 mole of compound X is warmed with alkaline iodine solution.
- 3 1 mole of compound X can only react with two moles of aqueous bromine.

- A 1 and 2 only B 1 and 3 only C 2 and 3 only D 1, 2 and 3

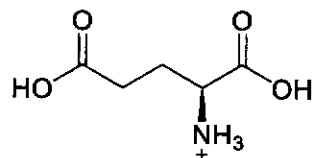
26 Which of the following reagents and conditions is the most suitable method to synthesise methanoic acid from methanol?

- A $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$, dilute $\text{H}_2\text{SO}_4(\text{aq})$, heat with distillation
- B $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$, dilute $\text{H}_2\text{SO}_4(\text{aq})$, heat under reflux
- C $\text{KMnO}_4(\text{aq})$, dilute $\text{H}_2\text{SO}_4(\text{aq})$, heat with distillation
- D $\text{KMnO}_4(\text{aq})$, dilute $\text{H}_2\text{SO}_4(\text{aq})$, heat under reflux

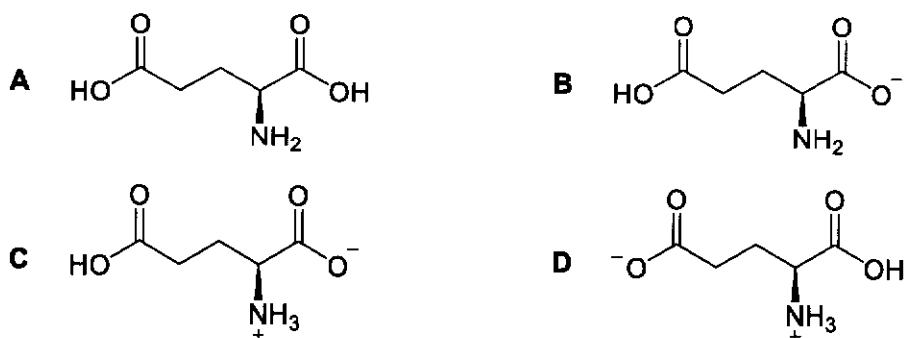
27 Which mixture could be used to produce propyl methanoate?

- A $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ and CH_3OH
- B $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ and HCO_2H
- C $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ and HCO_2H
- D $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$ and CH_3OH

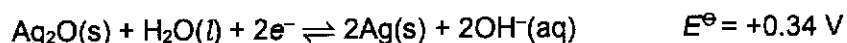
28 The fully protonated form of glutamic acid is shown, and has pK_a values of 2.10, 4.07 and 9.47 at 25 °C.



Which structure is predominant in an aqueous solution at $\text{pH} = 3.70$?



- 29 Button batteries, often used in watches and calculators, typically contain zinc and silver oxide electrodes. The half-cells involved are:



Which of the following statements about the button battery cell are correct?

- 1 Zinc is the negative electrode.
- 2 Electrons flow from $\text{Zn}^{2+}|\text{Zn}$ half-cell to $\text{Ag}_2\text{O}|\text{Ag}$ half-cell.
- 3 The ΔG^{\ominus} of the reaction is -106 kJ mol^{-1} .

- A 3 only B 1 and 2 only C 1 and 3 only D 1, 2 and 3
- 30 When a solution containing 0.10 mol of the compound, $\text{Cr}(\text{H}_2\text{O})_6\text{Cl}_3$, is treated with excess silver nitrate solution, 0.20 mol of silver chloride, AgCl , is immediately precipitated.

What is the formula of the complex ion in the compound?

- A $[\text{Cr}(\text{OH})_6]^{3-}$ B $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ C $[\text{CrCl}(\text{H}_2\text{O})_5]^{2+}$ D $[\text{CrCl}_2(\text{H}_2\text{O})_4]^+$

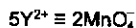
2024 JC2 Preliminary Examination
H2 Chemistry 9729
Paper 1 Worked Solution

1 mass of Fe in 0.32 g of Fe_2O_3

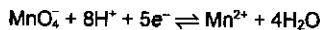
$$= \frac{2 \times 55.8}{2 \times 55.8 + 3 \times 16.0} \times 0.32 \text{ g} = 0.2238 \text{ g}$$
 % by mass of Fe in ore = $\frac{0.2238}{0.6} = 37.3\%$

⇒ B

2 $n_{\text{Y}^{2+}} = \frac{25.0}{1000} \times 0.400 = 0.0100 \text{ mol}$
 $n_{\text{MnO}_4^-} = \frac{40.00}{1000} \times 0.10 = 0.00400 \text{ mol}$



MnO_4^- is an oxidising agent, per mole, it takes in 5 moles of electrons:



$5\text{Y}^{2+} \equiv 10\text{e}^-$, each mole of Y^{2+} gives out 2 moles of electrons.

⇒ Final oxidation of Y is +4.

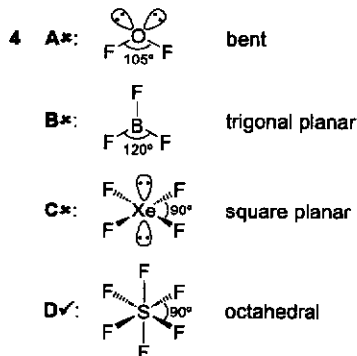
⇒ A

3

nuclide	charge, q mass, m
$^{24}\text{Mg}^{+}$	$\frac{1}{24} = 0.0417$
$^{48}\text{Tl}^{3+}$	$\frac{3}{48} = 0.0625$
$^{59}\text{Co}^{2+}$	$\frac{2}{59} = 0.0339$
$^{101}\text{Ru}^{4+}$	$\frac{4}{101} = 0.0396$

Since $^{48}\text{Tl}^{3+}$ has the largest $\frac{q}{m}$ ratio amongst the four nuclides, it will experience the greatest deflection.

⇒ B



⇒ D

5 Using $\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2} \Rightarrow p_2 = p_1 \times \frac{V_1}{V_2} \times \frac{T_2}{T_1}$

$p_K = 40 \text{ kPa} \times \frac{100 \text{ cm}^3}{(100 + 400) \text{ cm}^3} \times \frac{(227 + 273)\text{K}}{(227 + 273)\text{K}}$
 $= 8 \text{ kPa}$

$p_L = 20 \text{ kPa} \times \frac{400 \text{ cm}^3}{(100 + 400) \text{ cm}^3} \times \frac{(227 + 273)\text{K}}{(127 + 273)\text{K}}$
 $= 20 \text{ kPa}$

final pressure of mixture = $p_K + p_L$
 $= 8 \text{ kPa} + 20 \text{ kPa}$
 $= 28 \text{ kPa}$

⇒ A

6 1✓: Lattice energy is the energy released when 1 mole of ionic compound, $\text{KCl}(s)$, is formed from its constituent gaseous ions, $\text{K}^+(g)$ and $\text{Cl}^-(g)$. The lattice energy of potassium chloride is ΔH_3 .

2*: The enthalpy change of solution is the energy change when 1 mole of substance in its standard state, $\text{KCl}(s)$, is completely dissolved in a solvent to give a solution of infinite dilution, $\text{K}^+(aq)$ and $\text{Cl}^-(aq)$. The enthalpy change of solution of potassium chloride is ΔH_4 .

3✓: Enthalpy change of formation is the energy change when 1 mole of a substance in its standard state, $\text{KCl}(s)$, is formed from its constituent elements in their standard states, $\text{K}(s)$ and $\text{Cl}_2(g)$. The enthalpy change of formation of solid potassium chloride is $(\Delta H_1 + \Delta H_2 + \Delta H_3)$.

⇒ B

7 1✓: $(\Delta G_1 + \Delta G_2)$ is ΔG for dissolving of $\text{AgCl}(s)$ in $\text{NH}_3(aq)$; $(\Delta G_3 + \Delta G_4)$ is ΔG for dissolving of $\text{AgBr}(s)$ in $\text{NH}_3(aq)$. As solid AgCl is more soluble than solid AgBr in $\text{NH}_3(aq)$, the former must be more exergonic, i.e. ΔG is more negative. Thus, $(\Delta G_1 + \Delta G_2) < (\Delta G_3 + \Delta G_4)$.

2✓: Eqm 2 and 4 are identical, with Cl^- and Br^- being spectator ions:
 $\text{Ag}^+(aq) + 2\text{NH}_3(aq) \rightleftharpoons [\text{Ag}(\text{NH}_3)_2]^+(aq)$
 Hence, $\Delta G_2 = \Delta G_4$.

3*: From 2, $\Delta G_2 = \Delta G_4$.

4✓: Since solid AgCl is more soluble than solid AgBr in water, ΔG_1 must be more exergonic, i.e. more negative, than ΔG_3 . Thus $\Delta G_1 < \Delta G_3$.

⇒ A

8 **A***: Forward reaction of reaction 1 leads to the formation of Ag atoms, causing the photochromic glass to darken.

Reaction 2 and 3 together, is the backward reaction of reaction 1, catalysed by Cu^+ and Cu^{2+} . This removes Ag atoms, causing the glass to become transparent again.

Forward reaction of reaction 1 must be much faster than the backward reaction (reaction 2 + reaction 3) when intensity of UV light is high to ensure the glass darkens.

B*: The forward reaction of reaction 1 is only favoured when intensity of (high energy) UV light is high, showing that the forward reaction is endergonic, i.e. $\Delta G > 0$ (non-spontaneous)

C*: When glass darkens in UV light, $[\text{Ag}]$ increases while $[\text{Ag}^+]$ decreases, which will cause reaction 3 to be more spontaneous.

D*: The position of equilibrium of reaction 1 shifts to the right in strong UV light, leading to formation of Ag atoms which cause the photochromic glass to darken.

⇒ B

9 The fraction of molecules with energy greater than or equal to a certain energy E is represented by the area under the graph beyond E . So, $W+X+Y+Z = 1$.

When a catalyst is added, the activation energy is lowered. Hence, the fraction of molecules with energy greater than or equal to activation energy for the catalysed reaction will be $X+Y+Z$.

⇒ C

10 1*: Rate is a kinetics property related to E_a , while K_c is a thermodynamics property related to ΔG . They are independent of each other.

2*: The temperature of the solution does not change since boiling point of water is also at 373 K. Therefore, there is no change in the K_c value.

3✓: The presence of a catalyst will not change the K_c value.

⇒ A

11 **A***: As T increased, amount of **A** remaining at equilibrium increased. This shows that position of equilibrium shifts left, hence backward reaction is endothermic. Forward reaction is thus exothermic.

B*: Position of equilibrium shifts left with increasing T to favour endothermic reaction. Thus K_p will decrease with increasing T .

C*: At 650 °C, amount of **A** remaining is 0.8 mol. Thus, 1.2 mol of **A** had decomposed. Percentage of **A** decomposed is $\frac{1.2}{2.0} \times 100 = 60\%$.

D*: The amount of **A** used up is 1.2 mol and hence amount of **C** produced is 1.2 mol at equilibrium.

⇒ B

12 $[\text{H}^+] = 10^{-2} = 0.0100 \text{ mol dm}^{-3}$

$[\text{H}^+] \text{ after mixing} = \frac{0.0100V + 0.0100V}{V + V + 2V}$
 $= 0.00500 \text{ mol dm}^{-3}$

$\text{pH} = -\lg[\text{H}^+] = -\lg(0.00500) = 2.3$

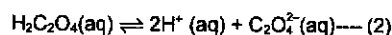
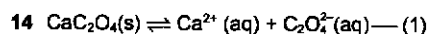
⇒ C

13 For a weak acid, HA,

$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]} \approx \frac{[\text{H}^+][\text{salt}]}{[\text{acid}]}$

Hence, $[\text{H}^+] \approx K_a \frac{[\text{acid}]}{[\text{salt}]}$

⇒ C



As pH increases, $[\text{H}^+]$ decreases. Hence the position of eqm (2) shifts to the right, causing $[\text{C}_2\text{O}_4^{2-}]$ to increase. This will cause the position of equilibrium for eqm (1) to shift to the left, reducing the solubility of $\text{CaC}_2\text{O}_4(s)$.

⇒ D

15 **A***: Although nuclear charge increases, shielding effect is similar due to same number of inner shell electrons, hence, effective nuclear charge increased, leading to the general decrease in atomic radius across the period.

B*: First ionisation energy generally increases due to increase in effective nuclear charge, however there is a decrease from Mg to Al (due to electron being removed from 3p

instead of 3s orbital), and from P to S (due to interelectronic repulsion between paired electrons).

C✓: +1 in Na₂O, +2 in MgO, +3 in Al₂O₃, +4 in SiO₂, +5 in P₄O₁₀, +6 in SO₃

D*: NaCl and MgCl₂ are ionic chlorides with higher melting points than the covalent AlCl₃, SiCl₄ and PCl₅.

⇒ C

16 The solubility of a salt is related to $\Delta G_{sol} = \Delta H_{sol} - T\Delta S_{sol}$ where $\Delta H_{sol} = |L.E.| - |\Sigma\Delta H_{hyd}|$

A*: The charge density of Mg²⁺ is indeed higher such that Mg²⁺ is better at organising water molecules around it, which leads to a more negative ΔS_{sol} . So, if ΔS_{sol} is more negative, then ΔG_{sol} is more positive for MgC₂O₄, which means that MgC₂O₄ should be less soluble instead.

B✓: Mg²⁺ has a higher charge density and forms stronger ion-dipole interaction and hence ΔH_{hyd} is more negative. This potentially contributes to a more negative ΔH_{sol} , which implies a more negative ΔG_{sol} and greater solubility.

C*: While it is true that Mg²⁺ has a more negative L.E. due to Mg²⁺ having a smaller ionic radius than Ca²⁺, a more negative L.E. leads to a more positive ΔH_{sol} and hence lower ΔG_{sol} .

D*: While this is true, electronegativity does not affect solubility.

⇒ B

17 1✓: As the atomic radius ↑es down the group, the valence orbitals used for bonding are larger and more diffused. This leads to less effective overlap of orbitals, resulting in X-X bond energy ↓ing down the group.

2✓: The number of electrons ↑es down the group, resulting in ↑ polarisability of electron cloud and thus strength of the id-id interactions. Hence volatility ↓es (higher boiling point) down the group.

3*: $E^{\ominus}(X_2|X^-)$ ↓es down the group, there is a ↓ in tendency for X₂ to be reduced. Oxidising power of Group 17 elements ↓es, i.e. they become weaker oxidising agents down the group.

⇒ B

18 A*: Compound R has 5 chiral centres, hence 2⁵ = 32 stereoisomers.

B*: Compound R and S have exactly the same connectivity of atoms.

C✓: HO(CH₂)₁₃OH cannot rotate plane polarised light since it has a plane of symmetry.

D*: Since the line structure of compound R does not possess any plane of symmetry and it has an odd number of chiral centres, none of its stereoisomers can exist as a meso compound.

⇒ C

19 A*: C-F (485 kJ mol⁻¹) is much stronger than C-Cl (340 kJ mol⁻¹). Hence Cl• and •CCF₂ are the major free radicals instead.

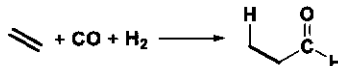
B✓: Adding step 1 (×2) to step 2, we get 2O₃ → 3O₂. X• acts as a catalyst in the breakdown of O₃ to O₂.

C*: Termination step involves the combination of two radicals, leading to the removal of radical species.

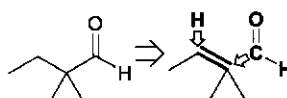
D*: Being smaller in size, F• should be more reactive than Cl•.

⇒ B

20 The oxo reaction can be seen as the addition of -H and -CHO across the C=C:

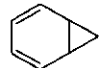


To obtain CH₃CH₂C(CH₃)₂CHO:



⇒ A

21 A*: Alkenes are stronger nucleophiles, since alkene can react with HBr at r.t., but not benzene.

B✓: There is no cyclic ring of overlapping p orbitals in , and hence

the stable aromatic structure is destroyed, making this reaction highly unfavourable.

C*: The C=C in an alkene (610 kJ mol⁻¹) is stronger than the C=C in benzene (520 kJ mol⁻¹), which makes this statement false.

D*: The directing effect of substituents is not involved in the cyclopropane formation.

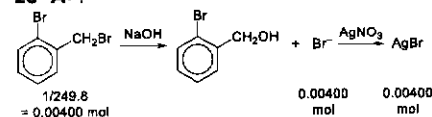
⇒ B

22 The bond strength of the C-X bond determines the rate of hydrolysis. The stronger the C-X bond, the harder it is to undergo hydrolysis.

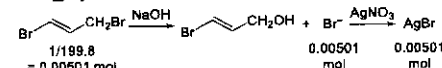
In addition, halogenoarenes are resistant to hydrolysis due to the lone pair of electrons on X delocalising into benzene ring which results in the partial double bond between C and X, strengthening the bond.

⇒ A

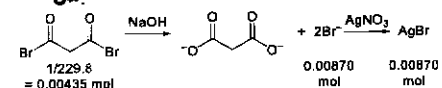
23 A*:



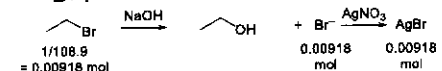
B*:



C*:



D✓:



⇒ D

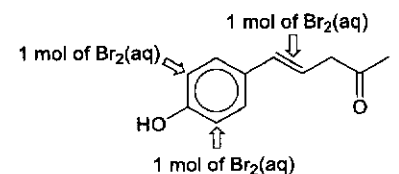
24 2-methylpropan-1-ol and butan-1-ol are primary alcohols that can be oxidised, but they do not give a positive test with alkaline aqueous iodine. 2-methylpropan-2-ol is a tertiary alcohol that does not undergo oxidation. Only butan-2-ol can be oxidised and has the methyl alcohol group that gives a positive test with alkaline aqueous iodine.

⇒ D

25 1✓: C=C undergoes oxidative cleavage with KMnO₄/H⁺, decolourising it.

2✓: 1 mol of -COCH₃ gives 1 mol of CHI₃ with alkaline iodine solution.

3*: 1 mol of X reacts with 3 mol of Br₂(aq)



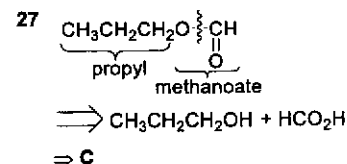
⇒ A

26 A*: HCHO will be distilled first before methanoic acid is formed.

B✓: HCO₂H is formed as K₂Cr₂O₇ is a milder oxidising agent than KMnO₄. CH₃OH + 2[O] → HCO₂H + H₂O

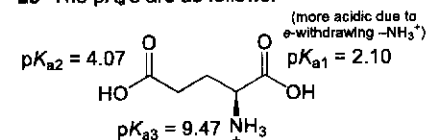
C, D*: KMnO₄ is a stronger oxidising agent and further oxidises HCO₂H: HCO₂H + [O] → H₂CO₃ → CO₂ + H₂O

⇒ B



⇒ C

28 The pK_a's are as follows:



pH 3.70 is closer to pK_{a2} than pK_{a1}, hence it has passed the first equivalence point, but before the second point of maximum buffer capacity. So the predominant form is where the most acidic proton is removed.

⇒ C

29 1✓: Since E[⊖](Zn²⁺|Zn) is more negative, zinc will undergo oxidation and hence, it is the negative electrode.

2✓: Since E[⊖](Zn²⁺|Zn) is more negative, Zn is oxidised to Zn²⁺ and electrons flow from the Zn²⁺|Zn half-cell (anode) to the Ag₂O|Ag half-cell (cathode).

3*: $\Delta G^{\ominus} = -2 \times 96500 \times (0.34 - (-0.76)) = -212.3 \text{ kJ mol}^{-1}$

⇒ B

30 0.10 mol of Cr(H₂O)₆Cl₃ gives 0.20 mol AgCl means there are 2 Cl⁻ per Cr³⁺ not acting as ligand. Hence, the complex is [CrCl(H₂O)₅]²⁺(Cl⁻)₂.

⇒ C

Answer Key

Qn	Ans	Qn	Ans	Qn	Ans
1	B	11	B	21	B
2	A	12	C	22	A
3	B	13	C	23	D
4	D	14	D	24	D
5	A	15	C	25	A
6	B	16	B	26	B
7	A	17	B	27	C
8	B	18	C	28	C
9	C	19	B	29	B
10	A	20	A	30	C