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Section A

For each question, there are four possible answers **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 1 When 10.0 cm³ of a 0.10 mol dm⁻³ solution of alkali metal salt **MX**O₃ was reduced with an excess of acidified potassium iodide solution, the resulting iodine required 60.0 cm³ of 0.10 mol dm⁻³ sodium thiosulfate solution for its reduction. The anion could be reduced to
 - **A X**O₂
 - **B X**O²⁻
 - **C X**O⁻
 - $\mathbf{D} \mathbf{X}^{-}$
- 2 10 cm³ of a hydrocarbon is mixed with 100 cm³ of oxygen gas which is in excess. The mixture is exploded and after it is cooled to room temperature, the residual gases occupy a volume of 80 cm³. Upon passing the gases through potassium hydroxide, this volume decreases to 50 cm³. What is the formula of the unknown hydrocarbon?
 - **A** C₃H₆
 - **B** C₃H₈
 - $C = C_4 H_8$
 - **D** C₄H₁₀

3 The use of Data Booklet is relevant to this question.

The successive ionisation energies, in kJ mol⁻¹, of an element **X** are given below.

870 1800 3000 3600 5800 7000 13200

What is element **X**?

- **A** ₃₃As
- **B** ₅₃I
- **C** 80
- **D** ₅₂Te
- **4** A 10.0 dm³ sample of oxygen at a pressure of 250 kPa and 3.0 dm³ sample of nitrogen at a pressure of 500 kPa are introduced into a 2.5 dm³ vessel at room temperature. What is the total pressure in the vessel?
 - A 750 kPa
 - **B** 1200 kPa
 - **C** 1600 kPa
 - **D** 1950 kPa
- 5 Given that the standard enthalpy change of combustion of but-1-ene and ethene are p and q kJ mol⁻¹ respectively. What is the standard enthalpy change of the reaction: $2C_2H_4(g) \rightarrow C_4H_8(g)$?
 - **A** $2\boldsymbol{q} \boldsymbol{p}$ kJ mol⁻¹
 - **B** (p + q)/2 kJ mol⁻¹
 - **C** q 2p kJ mol⁻¹
 - **D** $(q p)/2 \text{ kJ mol}^{-1}$

6 The data below refers to the standard molar enthalpy changes of combustion of some members of the alkanes.

Alkane	$\Delta H_{c}^{\theta}/kJ \text{ mol}^{-1}$
CH_4	-890
C_2H_6	-1560
C ₃ H ₈	-2220
C ₄ H ₁₀	-2880
C ₅ H ₁₂	-3510
C ₆ H ₁₄	-4190

Another alkane **X** has a standard enthalpy change of combustion of $-6780 \text{ kJ mol}^{-1}$. The formula of **X** is likely to be

- **A** C₉H₂₀
- $B = C_{10}H_{22}$
- **C** C₁₁H₂₄
- $D = C_{12}H_{26}$
- 7 The data below refers to the radii and charges of six ions.

lon	P ²⁺	Q ⁺	R⁺	T ^{2–}	U⁻	V-
Radius/nm	0.16	0.19	0.15	0.16	0.19	0.15

PT, **QU** and **RV** are ionic solids of the same lattice structure. Which one of the following gives the correct order of their lattice energies with the lowest numerical value first?

Α	PT	RV	QU
В	PT	QU	RV
С	RV	QU	РТ
D	QU	RV	РТ

8 In the presence of ultraviolet light, the "inert" xenon gas will react with fluorine gas to produce XeF_4 according to the equation,

 $Xe(g) + 2F_2(g) \longrightarrow XeF_4(s)$

What is the correct equilibrium constant K_c ?

9



The decomposition of dinitrogen pentoxide N_2O_5 is found to be first order with respect to the concentration of N_2O_5 . Which one of the following graphs confirms the results?



- **10** What is the pH of the final solution formed by mixing equal volumes of two separate portions of dilute sulfuric acid of pH 2.0 and pH 4.0?
 - **A** 2.3
 - **B** 2.6
 - **C** 3.0
 - **D** 3.6
- 11 Hydrogen iodide is not prepared by the addition of concentrated sulfuric acid to solid sodium iodide. This can be best explained by the fact that
 - A Hydrogen iodide is not displaced by sulfuric acid.
 - **B** lodide ions are oxidised to iodine.
 - **C** Sodium sulfide is formed as an impurity.
 - **D** Hydrogen iodide is less volatile than concentrated sulfuric acid.
- **12** Which one of the following gives the correct definition of an acid according to the Bronsted-Lowry theory?
 - **A** It dissociates in water to give $H^+(aq)$ ions.
 - **B** It is a proton donor.
 - **C** It is a proton acceptor.
 - **D** It is an electron donor.

13 The graph below shows the variation in the boiling points for eight consecutive elements in the Period Table, all with atomic numbers from 10 to 20. The letters do not represent any element in the Periodic Table.



Which of the following can be deduced from the graph above?

- A Element H forms an acidic oxide only.
- B Element K does not conduct electricity.
- **C** Element **G** can exist in two allotropic forms.
- **D** Element **E** and beryllium are in the same group.
- 14 A typical chemical reaction is acid catalysed, and the reaction is first order with respect to the hydrogen ion. If all other conditions are kept constant, what is the ratio of <u>rate of reaction at pH 3</u>?
 - **A** 0.01
 - **B** 0.33
 - **C** 1
 - **D** 3

- **15** Consider the following four compounds:
 - (I) (CH₃)₃CH
 - (II) $CH_3CH_2CH_2OH$
 - (III) $CH_3CH_2CH_2SH$
 - $(IV) \quad CH_3CH_2CH_2CH_3$

What is the order of increasing boiling point of the compounds?

- **A** I, IV, III, II
- **B** I, IV, II, III
- **C** II, III, IV, I
- **D** III, II, IV, I
- **16** Which one of the following statements would **not** be expected for Group II elements or its compounds?
 - **A** Barium sulfate has numerically smaller lattice energy than magnesium sulfate.
 - **B** Beryllium forms compound with the least covalent character.
 - **C** Barium oxide in water produces an equilibrium with high $K_{\rm b}$.
 - **D** The heating of nitrates of Group II compounds will result in an increase in entropy.
- **17** Which one of the following statements about Group II elements is correct?
 - **A** The reactivity with cold water decrease down the Group.
 - **B** The charge density of Group II cations increases from Be to Ba.
 - **C** The minimum temperature for the thermal decomposition of Group II nitrates increases down the Group.
 - **D** The melting point of Group II carbonates decrease down the Group due to the decreasing polarising power of cations.

- **18** Which one of the following statement is true of vanadium and its compound?
 - **A** The maximum oxidation state of vanadium is found in VO^{2+} .
 - **B** V_2O_5 is used as a catalyst in the manufacture of ammonia.
 - **C** Zinc reduces $VO_2^+(aq)$ to $V^{2+}(aq)$.
 - **D** Vanadium is less dense than calcium.
- **19** Which of the following statement describes a phenomenon which can be explained by intermolecular hydrogen bonding?
 - A Ammonia is very soluble in water.
 - **B** CH_3OCH_3 (M_r = 46) has a higher boiling point than $CH_3CH_2CH_3$ (M_r = 44).
 - **C** Hydrogen chloride forms an acidic solution when dissolved in water.
 - **D** The boiling points of the alkanes increase with increasing relative molecular mass.
- **20** A compound **Z** has the formula $Cr(H_2O)_6Cl_3$ and a relative formula mass of 266. A 10 cm³ solution containing 26.6 g dm⁻³ of **Z** requires 20 cm³ of 0.1 mol dm⁻³ AgNO₃ to completely precipitate the chloride ions. Which of the following is the correct structure for **Z**?
 - A $CrCl_3 \cdot 6H_2O$
 - **B** $CrCl_3[H_2O]_3 \cdot 3H_2O$
 - **C** $Cr[H_2O]_6^{3+}3Cl^{-}$
 - **D** $CrCl[H_2O]_5^{2+}2Cl^-H_2O$

21 Serotonin is a monoamine neurotransmitter.



Serotonin

How many sigma (σ) and pi (π) bonds does serotonin have?

- **A** 26 σ and 2 π
- **B** 26 σ and 4 π
- **C** 28 σ and 2 π
- **D** 28 σ and 4 π
- 22 Compound **P** is optically active.



How many chiral centre(s) does compound P have?

- **A** 1
- **B** 2
- **C** 3
- **D** 4

23 A student attempts to synthesise compound **S** from the following synthetic route.



Which of the following could be compound ${\boldsymbol{\mathsf{S}}}$ that is formed in this reaction?



24 An alcohol X, when treated with hot acidified aqueous potassium manganate(VII), gives a final oxidation product which reacts positively to the tri-iodomethane (iodoform) reaction. Which one of the following formula could be X?



- B C₂H₅OH
- C CH₃CH(OH)C₂H₅
- $D = C_6H_5CH(OH)C_2H_5$
- 25 Which one of the following represents the organic ion produced when an excess of hot aqueous sodium hydroxide is added to compound **R**?









- 26 Which one of the following, in alcoholic solution, produces a precipitate most rapidly when warmed with aqueous silver nitrate?
 - A chlorobenzene
 - B 1-iodobutane
 - C 1-bromobutane
 - D 1-chlorobutane
- 27 What is the total number of possible stereoisomers that can be formed when the following compound reacts with excess concentrated H_2SO_4 ?



- **A** 2
- **B** 4
- **C** 6
- **D** 8

28 Compound **Q** is subjected to the following tests and the results are recorded below.

reagents and conditions	observations
acidified KMnO ₄ and reflux	Purple solution turns colourless.
	Effervescence of colourless gas.
Fehling's reagent and warm	No precipitate seen.
Tollen's reagent and warm	Silver mirror is formed.

Which of the following could be compound Q?



- **29** The reduction of a nitrile produces a compound of formula C₃H₇NH₂. Which of the following would be produced if the same nitrile is heated with hydrochloric acid?
 - A CH₃CONH₂
 - B CH₃CH₂OH
 - C CH₃CH₂COOH
 - D (CH₃)₂CHCOOH

- **30** Separation of benzene from a mixture of benzene and an organic amine could involve
 - **A** Treating the mixture with dilute aqueous alkali.
 - **B** Treating the mixture with dilute aqueous acid.
 - **C** Extracting the amine with cyclohexanol.
 - **D** Extracting the benzene with diethyl ether ($CH_3CH_2OCH_2CH_3$).

Section B

For each question, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements which you consider to be correct).

The responses A to D should be selected on the basis of

Α	В	С	D
1, 2 and 3	1 and 2 only	2 and 3 only	1 only
are correct	are correct	are correct	is correct

No other combination of statements is used as a correct response.

31 The equilibrium constant K_p for the reaction

$$P(g) + 2Q(g) \rightarrow R(g)$$

is found to vary with temperature T as shown in the diagram below.



Which of the following conclusion(s) can be drawn from this information?

- 1 The reaction is exothermic in the forward direction.
- 2 The equilibrium mixture contains a high proportion of **R** at higher pressures.
- **3** The equilibrium mixture contains a high proportion of **R** at higher temperatures.

Α	В	С	D
1, 2 and 3	1 and 2 only	2 and 3 only	1 only
are correct	are correct	are correct	is correct

No other combination of statements is used as a correct response.

- 32 Which of the following system(s) contain/s delocalised electrons?
 - 1 cyclohexene
 - 2 graphite
 - **3** sodium
- **33** The table below shows the solubility product, in mol dm⁻³ for three metal sulfides. In an acidic solution, $[S^{2-}]_{saturated} = 10^{-18}$ mol dm⁻³.

Metal ion	Mn ²⁺	Ni ²⁺	Ag ⁺
K _{sp} of sulfide	10 ⁻¹⁶	10 ⁻²¹	10 ⁻³⁶

Which of the metal sulfides would be precipitated from the acidic solution containing 0.010 mol dm^{-3} of the metal ion when the solution is saturated with hydrogen sulfide?

- 1 Mn²⁺
- **2** Ni²⁺
- **3** Ag⁺

A	В	С	D
1, 2 and 3	1 and 2 only	2 and 3 only	1 only
are correct	are correct	are correct	is correct

No other combination of statements is used as a correct response.

34 When copper is electroplated with silver, a solution containing both silver nitrate and potassium cyanide, KCN, is used. The process involves the sequence shown below.

Which of the following statement(s) correctly describe this process?

- 1 The cyanide ions reduce the concentration of aqueous silver ions.
- **2** Both stages 1 and 2 involve a change of oxidation number.
- **3** The copper object will be the anode.
- **35** For this sequence: hydrogen chloride, hydrogen bromide and hydrogen iodide, there is a decrease in
 - 1 thermal stability
 - 2 bond length
 - **3** ease of oxidation

A	В	С	D
1, 2 and 3	1 and 2 only	2 and 3 only	1 only
are correct	are correct	are correct	is correct

No other combination of statements is used as a correct response.

36 Consider the following reaction scheme involving benzaldehyde and ammonia in methanol to form an imine.



Which of the following statement(s) is/are true?

- 1 Ammonia is the nucleophile in this reaction.
- 2 The rate of backward reaction is increased by the addition of H_2O .
- **3** The yield of imine is increased by the addition of NaOH to the reacting mixture of benzaldehyde and ammonia.
- **37** When iodoethane is heated to about 100°C in a sealed tube with concentrated ammonia solution, the possible product(s) is/are
 - 1 $C_2H_5NH_2$
 - **2** (C₂H₅)₂NH
 - **3** $(C_2H_5)_3N$

Α	В	С	D
1, 2 and 3	1 and 2 only	2 and 3 only	1 only
are correct	are correct	are correct	is correct

No other combination of statements is used as a correct response.

38 The compound below is Binapacryl which is often used as a fungicide.



Which of the following statement(s) is/are true about the fungicide?

- 1 It undergoes a more vigorous reaction with potassium metal than sodium metal.
- 2 It reacts with ethanoic acid in the presence of concentrated sulfuric acid to give a pleasant smelling liquid.
- 3 It cannot exist as a racemic mixture .
- **39** Vitamin B5 has the following structure.



Which of the following statement(s) correctly describe the chemistry of Vitamin B5?

- 1 Vitamin B5 reacts with 3 moles of PCl_5 .
- **2** The carboxylic acid group reacts with CH_3NH_2 to form an amide.
- **3** Vitamin B5 reacts with 2 moles of HCN.

Α	В	С	D
1, 2 and 3	1 and 2 only	2 and 3 only	1 only
are correct	are correct	are correct	is correct

No other combination of statements is used as a correct response.

40 *Psilocin* is a psychedelic mushroom alkaloid. It is the active compound that produces hallucinations from ingesting "magic mushrooms" and amplifies sensory experience. Compound **Y** is a derivative of *Psilocin*.



Which of the following statement(s) is/are true about Y?

- 1 It gives white fumes with CH_3COCl .
- 2 It dissolves in both aqueous acids and alkalis.
- **3** The nitrogen-containing group in the ring has a lower pK_b than the nitrogen-containing group in the side chain.