Section A

For each question, there are four possible answers: **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice.

- The oxide of a metal, MO, reacts with sulfuric acid to form its corresponding sulfate, MSO₄, and water. When 5 g of pure MO is reacted with 100 cm³ of 1 mol dm⁻³ of sulfuric acid, the excess acid required 21.45 cm³ of 1 mol dm⁻³ NaOH for complete neutralisation. Determine the A_r of the metal, M.
 - **A** 40.0
 - **B** 47.5
 - **C** 56.0
 - **D** 63.5
- 2. 70 cm³ of a mixture of methane and ethene were exploded in 200 cm³ of oxygen. The volume of the residual gases was found to be 130 cm³. On being shaken with sodium hydroxide, the final volume was found to be 35 cm³. What is the composition of the mixture? (*All volumes are measured at r.t.p*)

	Volume of methane / cm ³	Volume of ethene / cm ³
Α	20	50
В	35	35
С	45	25
D	50	20

- **3.** Which of the following species in their ground states have four unpaired electrons?
- 4. Element X has a valence electronic configuration of 2s² 2p¹ while element Y has a valence electronic configuration of 2s² 2p⁴. What is the formula of the compound formed between X and Y?
 - A XY B X₂Y₃
 - $C X_3Y_2$
 - $D X_3Y_6$
- 5. Which of the following compounds has the highest boiling point?
 - A NO₂
 - B SO₂
 - C SiO₂
 - **D** H₂O

6. The diagram below shows part of the structure of ordinary ice.



Which of the following statements is not true?

- **A** The bond angle in ice is 104.5° .
- **B** The density of water is higher than that of ice.
- **C** Ice has a cage-like "open" structure.
- **D** Both ice and water have covalent bonding as well as hydrogen bonding.
- A small spacecraft of capacity 20 m³ is connected to another of capacity 50 m³.
 Before connection, the pressure inside the smaller craft is 40 atm and that inside the larger is 150 atm.

If all measurements are made at the same temperature, what is the pressure in the combined arrangement after connection?

- A 190 atm
- **B** 119 atm
- **C** 95 atm
- **D** 78 atm

8. Which of the following diagrams correctly shows the graph of *V* against *T* for a fixed mass of ideal gas at constant pressure?



In an experiment to determine the enthalpy change of neutralisation of nitric acid,
 25 cm³ of solution containing 0.04 mol of HNO₃ is placed in a plastic cup of
 negligible heat capacity.

A 25 cm³ sample of aqueous sodium hydroxide containing 0.04 mol of NaOH, at the same initial temperature, is added and the temperature rises by 20 °C. If the heat capacity per unit volume of the final solution is 4.2 J K⁻¹ cm⁻³, what is the numerical value of the enthalpy change of neutralisation of nitric acid?

A
$$\frac{50 \times 4.2 \times (20 + 273)}{0.04}$$
B
$$50 \times 4.2 \times 20 \times 0.08$$
C
$$\frac{50 \times 4.2 \times 20}{0.04}$$
D
$$\frac{25 \times 4.2 \times 20}{0.08}$$

10. The use of the Data Booklet is relevant to this question.Hydrogen peroxide is commonly used as a bleaching agent in hair dyes and has the following structural formula.

What is the enthalpy change of atomisation of 1 mole of gaseous hydrogen peroxide?

- **A** 610 kJ mol⁻¹
- **B** 956 kJ mol⁻¹
- **C** 1070 kJ mol⁻¹
- **D** 1416 kJ mol⁻¹
- **11.** A titration is carried out between 10.0 cm³ of 0.05 mol dm⁻³ manganate(VII), MnO₄⁻, solution and 0.05 mol dm⁻³ of acidified methanoate, HCO_2^- solution. The products formed are MnO_4^{2-} and CO_3^{2-} . What is the volume (in cm³) of $HCO_2^$ required for complete reaction?
 - **A** 5.00
 - **B** 10.50
 - **C** 20.00
 - **D** 25.00

12. The use of the Data Booklet is relevant to this question.

Which of the following species can cause the oxidation of nickel, Ni?

- **A** Cr³⁺
- **B** Pb²⁺
- **C** Cu
- **D** C*l*⁻
- **13.** Two gases, **P** and **Q**, react as follows.

$$\mathbf{P}(g) + \mathbf{Q}(g) = 3\mathbf{R}(g)$$

A mixture containing \mathbf{P} and \mathbf{Q} is heated in a 2 dm³ closed vessel and the reaction is allowed to reach equilibrium. The following graph shows how the number of moles of each gas varies with time.



What is the value of the equilibrium constant K_c for this reaction?

- **A** 0.372
- **B** 0.744
- **C** 0.778
- **D** 1.286

14. Which of the following options is correct for the following equilibrium?

 $3H_2(g) + N_2(g) = 2NH_3(g) \Delta H = -92 \text{ kJ mol}^{-1}$

	Condition	Position of equilibrium	Kp	Rate of forward reaction
Δ	Increase in	Right	Increase	Increase
	temperature			
в	Addition of catalyst	No change	No	No change
			change	
C	Decrease in pressure	Left	No	Decrease
Ŭ			change	
D	Addition of H ₂ (g)	Right	Increase	Increase

- **15.** Given that the K_{sp} for silver hydroxide, AgOH, is 1.52 x 10⁻⁸ mol² dm⁻⁶ at 298 K, calculate the pH of the solution at equilibrium.
 - **A** 2.6
 - **B** 3.9
 - **C** 10.1
 - **D** 11.4
- **16.** Calculate the pH of a buffer solution made by dissolving 8.2 g of sodium ethanoate (CH_3COONa) in 500 cm³ of 0.100 mol dm⁻³ ethanoic acid.

($K_{\rm b}$ for ethanoate ion = 5.71 x 10⁻¹⁰ mol dm⁻³)

- **A** 4.06
- **B** 5.06
- **C** 9.24
- **D** 9.54

17. Radioactive decay is a first order reaction.

Carbon-14 is a radioactive element with a half-life of 5600 years. A piece of wood, containing carbon-14, from an ancient ship gives a count of 10 counts per minute, while carbon-14 obtained from new wood gives 15 counts per minute. What is the age of the ship?

- A 2800 years
- **B** 3276 years
- **C** 3733 years
- D 8876 years
- **18.** The table below gives data for the reaction between **Q** and **R** at constant temperature.

Experiment	[Q]	[R]	initial rate
	/ mol dm ⁻³	/ mol dm ⁻³	/ mol dm ⁻³ s ⁻¹
1	0.3	0.2	4.0 × 10 ⁻⁴
2	0.6	0.4	1.6 × 10 ⁻³
3	0.6	0.8	6.4 × 10 ⁻³

What is the units of the rate constant for the reaction?

- **A** $mol^2 dm^{-6} s^{-1}$
- **B** mol⁻² dm⁶ s⁻¹
- **C** mol dm⁻³ s⁻¹
- **D** mol⁻¹ dm³ s⁻¹
- **19.** Which of the following trend across Period 3 (Na to C*l*) is always true?
 - A The electrical conductivity of the element decreases.
 - **B** The bonding in the oxides changes from ionic to covalent.
 - **C** The melting point of the oxides decreases.
 - **D** The electronegativity of the elements decreases.
- **20.** The following elements are reacted with oxygen and the products are dissolved in water. The element which produces the solution with the greatest pH is
 - A Na
 - B Al
 - **c** s
 - **D** P

21. How do the values of lattice energy and enthalpy change of hydration vary for Group II carbonates from magnesium to barium?

	Lattice energy	Enthalpy change of hydration
Α	less exothermic	less exothermic
В	less exothermic	more exothermic
С	more exothermic	less exothermic
D	more exothermic	more exothermic

- **22.** Which of the following features of transition metals or their compounds make them suitable as heterogeneous catalysts for chemical reactions?
 - **A** They have variable oxidation states.
 - **B** They form stable complexes.
 - **C** They have available 3d and 4s orbitals.
 - **D** They can undergo ligand exchange reactions.
- **23.** Which of the following pairs of compounds can be attacked by cyanide ions via nucleophilic reactions?
 - A CH₃CH₂Cl and CH₃COCH₂CH₃
 - **B** CH₃CH₂Cl and CH₃COOCH₃
 - **C** C_6H_5Cl and $CH_3COCH_2CH_3$
 - **D** C_6H_5Cl and CH_3COOCH_3
- 24. Acarol is the active ingredient in many insecticides.



Acarol

Which of the following statements about Acarol is true?

- A Acarol exhibits stereoisomerism.
- **B** Acarol forms white fumes with thionyl chloride.
- **C** Acarol changes hot, acidified $K_2Cr_2O_7$ from orange to green.
- **D** Acarol forms an orange precipitate with 2,4 dinitrophenylhydrazine.

25. Cannabis is a psychoactive drug which accumulates in the fatty tissues of the body.Compound W can be prepared from cannabis as shown in the following reaction sequence.



Which of the following reagents can be used to prepare compound **W**?

	Step I	Step II
Α	Na ₂ CO ₃	CH ₂ (OH)CH ₂ COOH
В	NaOH	CH ₂ C <i>l</i> CH ₂ COOH
С	Na	CH ₂ (OH)CH ₂ CH ₂ COOH
D	NaOH	CH ₂ C <i>l</i> CH ₂ CH ₂ COOH

26. When propene reacts with Br₂ in the presence of excess aqueous KNO₃, what are the two major products formed?



27. Which of the following reactions would not produce 1,3-dicarboxylic acid?



- 13
- **28.** The diagram represents a section of a catalytic converter on the exhaust system of a car. Harmful gases are converted into carbon dioxide, nitrogen and water vapour.



Which statement about the catalytic convertor is not true?

- **A** NO_x are reduced to N_2 by the excess CO present.
- **B** Cars fitted with a catalytic converter may run on leaded petrol.
- **C** Platinum and rhodium catalyse redox reactions.
- **D** Platinum and rhodium are coated on a ceramic honeycomb structure so as to maximise surface area.
- **29.** The amino acids lysine and glutamine can react with each other to form peptide linkages.



lysine

glutamine

What is the maximum number of different compounds, each containing one peptide linkage that can be formed from one molecule of lysine and one molecule of glutamine?

A 2
B 3
C 4
D 5

30. X possesses a chiral centre and forms a zwitterion. Which one of the following structures could **X** be?



15 Section B

For each of the questions in this section, 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 that you consider to be correct).

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

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

No other combination of statements is used as a correct response

- 31. Which of the following species are linear?
 - **1** I_3^-
 - **2** CO₂
 - **3** SO₂
- **32.** Which of the following reactions does the value of △H° represent both a standard enthalpy change of formation and standard enthalpy change of combustion?
 - $\label{eq:constraint} \mathbf{1} \qquad \mathrm{C}(s) \ + \ \mathrm{O}_2 \ (g) \ \rightarrow \ \mathrm{CO}_2(g)$
 - $\label{eq:2} {\bf 2} \qquad H_2(g) \ + \ {}^{1\!\!\!/_2} \, O_2(g) \ \to \ H_2O(g)$
 - ${\bf 3} \qquad CO(g) \ + \ {}^{1\!\!/_2} O_2 \ (g) \ \to \ CO_2(g)$
- **33.** Acidified KMnO₄ is used as an oxidizing agent for alkenes. Which of the following acids can be used to acidify KMnO₄?
 - 1 Sulfuric acid, H₂SO₄
 - **2** Hydrochloric acid, HC*l*
 - **3** Ethanedioic acid, H₂C₂O₄

16					
Α	В	С	D		
1, 2, and 3 are	1 and 2 only are	2 and 3 only are	1 only is correct		
correct	correct	correct			

34. When 25.0 cm³ of a 0.100 mol dm⁻³ solution of NH_3 was titrated with a 0.100 mol dm⁻³ HC*l* solution, the following titration curve was obtained. Which of the following statements are correct about this titration?



- 1 The approximate pH at equivalence point, **C**, is above 7.
- 2 A basic buffer is formed at point **B**.
- **3** The $K_{\rm b}$ for the NH₃ solution is 1.58 x 10⁻⁵ mol dm⁻³ if the pH at point **A** is 11.1.
- 35. The reaction of acidified, aqueous potassium iodide with aqueous hydrogen peroxide

 $2I^{-}(aq) + H_2O_2(aq) + 2H^{+}(aq) \rightarrow I_2(aq) + 2H_2O(l)$

is thought to involve the following steps:

H_2O_2 + $I^- \rightarrow H_2O$ + OI^-	(slow)
$OI^{-} + H^{+} \rightarrow HOI$	(fast)
$HOI ~+~ H^{*} ~+~ I^{-} ~\rightarrow~ I_{2} ~+~ H_{2}O$	(fast)

Which of the following conclusions can be drawn from the above information?

- 1 The rate equation for the reaction is: rate = $k [H_2O_2] [I^-]$
- 2 Hydrogen peroxide is reduced by the iodide ion.
- 3 The acid acts as a catalyst.

17					
Α	В	С	D		
1, 2, and 3 are	1 and 2 only are	2 and 3 only are	1 only is correct		
correct	correct	correct			

- **36.** Which of the following suggestions concerning the element astatine, At, are consistent with its position in Group VII?
 - 1 NaAt forms a precipitate with $AgNO_3$ which is insoluble in aqueous NH_3 .
 - **2** At₂ is the weakest oxidising agent in Group VII.
 - **3** At₂ is a liquid at 25° C and 1 atm.
- **37.** Thyroxine and Cyproterone are compounds that are often used in hormone therapy.



Thyroxine

Cyproterone

Which of the following reagents could be used to distinguish between the two compounds?

- 1 Neutral FeCl₃
- 2 Alkaline aqueous iodine
- 3 Sodium carbonate
- **38.** Which of the following properties of benzene may be directly attributed to the stability associated with the delocalised electrons?
 - 1 Its susceptibility to attack by nucleophilic reagents.
 - 2 Its tendency to undergo substitution rather than addition reactions.
 - **3** The carbon-carbon bond lengths are between those of C-C bonds and C=C bonds.

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

18

- **39.** By varying the conditions of the reaction between propan-1-ol and concentrated sulfuric acid, which of the following compounds can be obtained?
 - 1 CH₃CH=CH₂
 - 2 CH₃CH₂CH₂OCH₂CH₂CH₃
 - **3** CH₃CH₂CH₂OSO₃H
- 40. Compound Q, with molecular formula C₆H₁₂, was reacted with acidified potassium manganate(VII) and the resultant mixture obtained was colourless. The mixture was thereafter distilled to form distillate R and residual solution S.

Distillate **R** is able to form a yellow precipitate with alkaline aqueous iodine. Residual solution **S** reacts with sodium carbonate to form a colourless gas.

Which of the following statements are true?

- 1 Compound **Q** will decolourise aqueous bromine
- 2 Distillate R can form an orange precipitate with 2,4-dinitrophenylhydrazine
- **3** Residual solution **S** can form white fumes with PCl_5 .

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