Section A

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

1. Which molecule has six bonding electrons?

Α	C_2H_4	С	H_2S
В	CO ₂	D	NC <i>I</i> ₃

2. Which of the following ions has the smallest ionic radius?

Α	F ⁻	С	Na ⁺
В	Mg ²⁺	D	A/ ³⁺

3. Consider the following half-equations.

Fe $^{2\text{+}} \rightarrow$ Fe $^{3\text{+}}$ + e

 $C_2O_4 \overset{2-}{\to} 2CO_2 + 2e$

What volume of 0.01 mol dm⁻³ $K_2Cr_2O_7$ is required to oxidise 20 cm³ of an acidified solution of 0.01 mol dm⁻³ FeC₂O₄?

Α	10 cm ³	С	30 cm ³
В	20 cm ³	D	40 cm ³

4. Which one of the following graphs below shows the correct plot of pV against p for a fixed mass of ideal gas at two temperatures, T_1 and T_2 , in which $T_1 > T_2$?



5. A student used the apparatus below to determine the enthalpy change of combustion of propan-1-ol.



The following results were obtained: mass of propan-1-ol burnt = 0.60 gmass of water heated = 200 ginitial temperature of water = 21.0°C

Given that the enthalpy change of combustion propan-1-ol is $-2021 \text{ kJ mol}^{-1}$ and the heat capacity of water is 4.17 J K⁻¹ g⁻¹, what would be the final temperature of the water?

Α	24.2 °C	С	29.1 °C
В	45.2 °C	D	48.4 °C

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6. The radius and charge of each of six ions are shown below:

lon	A+	B⁺	C ²⁺	X-	Y-	Z ^{2–}
Radius / nm	0.21	0.27	0.23	0.21	0.27	0.23

The ionic solids AX, BY and CZ are of the same lattice type.

What is the correct order of their lattice energies placing the one with the highest numerical value first?

Α	CZ > AX > BY	С	CZ > BY > AX
В	AX > CZ > BY	D	AX > BY > CZ

7. The table below shows the standard thermodynamic values for the synthesis of hydrogen chloride: $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$.

ΔH^{Θ}	-184.6 kJ mol ⁻¹
ΔS^{Θ}	+0.02 kJ K ⁻¹ mol ⁻¹

From the data, what is the value of ΔG^{e} ?

Α	+178.6 kJ mol ⁻¹	С	-185.1 kJ mol⁻¹
В	-178.6 kJ mol ⁻¹	D	-190.6 kJ mol ⁻¹

- 8. How would the magnitude of the following vary down Group II?
 - (i) the standard electrode potential of $M^{2+}(aq)/M(s)$ electrode, E^{e}
 - (ii) the lattice energy of the oxide, ΔH^{e}_{latt}
 - (iii) the standard enthalpy change of hydration of $M^{2+}(g)$, ΔH^{e}_{hvd} .

	E ^e M ²⁺ /M	ΔH_{latt}^{Θ} of MO(s)	ΔH^{Θ}_{hyd} of $M^{2+}(g)$
Α	increases	decreases	decreases
В	decreases	decreases	increases
С	increases	increases	decreases
D	increases	increases	increases

9. The mechanism for a certain reaction is given below:

2A = C	(fast)
$C + B \rightarrow D$	(slow)
$D+B\toA_2B_2$	(fast)

What conclusion can be drawn from the above mechanism?

- **A** The rate equation is rate = k[C][B].
- **B** The units of the rate constant, k, is mol⁻² dm⁶ s⁻¹.
- **C** The reaction is first order with respect to **D**.
- **D** The overall equation is $2\mathbf{A} + 2\mathbf{B} + \mathbf{C} + \mathbf{D} \rightarrow \mathbf{A}_2\mathbf{B}_2$.
- 10. The diagrams P, Q, R and S show how a change in conditions affects the Maxwell-Boltzmann distribution of molecular energies for gas G. In each case, the original distribution is shown by a solid line and the distribution after a change has been made is shown by a dashed line.



Which one of the following statements is correct?

- A the change shown in diagram **Q** occurs when a catalyst is used.
- **B** the change shown in diagram **R** occurs when the temperature is increased.
- **C** the change shown in diagram **P** occurs when the temperature is decreased.
- **D** the change shown in diagram **S** occurs when the pressure of **G** is decreased at constant temperature

11. Using a colorimeter, the following reaction is studied by finding the time taken for a coloured reactant, **A**, to decolourise. The reaction is catalysed by **Y**.

$$\mathbf{A} + \mathbf{B} \rightarrow \mathbf{C} + \mathbf{D}$$

The following results are obtained.

Experiment	Volume of	Volume of	Volume of Y	Volume of	Time taken
	A added /	B added /	added / cm ³	H ₂ O added /	/ s
	cm ³	cm ³		cm ³	
1	10	20	10	10	20
2	10	10	10	20	40
3	10	20	5	15	40
4	5	20	10	15	20

What is the rate equation for the reaction?

Α	rate = k[B][Y]	С	rate = k[B]
В	rate = k[A][Y]	D	rate = k[A][B][Y]

12. $CH_3COOH + C_2H_5OH \Rightarrow CH_3COOC_2H_5 + H_2O$

The above reaction can be said to have reached dynamic equilibrium when

- **A** the equilibrium constant K is equal to 1.
- **B** the reaction between the acid and the alcohol has stopped.
- **C** the concentrations of the products equal those of the reactants.
- **D** the rate of production of ethyl ethanoate equals its rate of hydrolysis.
- **13.** The pH change during a titration when a monobasic acid is added dropwise to 20.0 cm³ of NaOH is shown below.



Volume of acid added/cm³

Which statement about the titration is correct?

- A Both an acidic and basic buffer can be formed at different points during this titration.
- **B** Both phenolphthalein and methyl orange can be used as an indicator for this titration.
- **C** Ethanoic acid is used in this titration and it has a pK_a value of less than 4.
- **D** Benzoic acid is used in this titration and it has a similar concentration as NaOH.
- What is the pH of an aqueous solution containing 0.1 mol dm⁻³ sodium benzoate and 0.01 mol dm⁻³ benzoic acid? [K_a (benzoic acid) = 6 x 10⁻⁵ mol dm⁻³]

Α	3.22	С	4.78
В	4.22	D	5.22

15. Public swimming pools are often chlorinated to kill bacteria. As an alternative to chlorination, silver ions can be used in a concentration of not more than 10⁻⁶ mol dm⁻³ and not less than 10⁻⁷ mol dm⁻³ of silver ions.

Which of the following compounds would, in saturated solution, provide the necessary concentration of silver ion?

	compound	solubility product
Α	AgBr	5 x 10 ⁻¹³ mol ² dm ⁻⁶
В	AgC <i>l</i>	2 x 10 ⁻¹⁰ mol ² dm ⁻⁶
С	AglO ₃	$2 \times 10^{-8} \text{ mol}^{2} \text{ dm}^{-6}$
D	Ag ₂ CO ₃	5 x 10 ⁻¹² mol ³ dm ⁻⁹

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

Studies have shown that the corrosion of copper hulls of sea-going ships could be prevented by placing strips of 'sacrificial metals' on the hulls. Which metal is least likely to dissolve when attached to the copper hull of a sea-going ship?

Α	iron	С	tin
В	magnesium	D	zinc

- **17.** During electrolysis under suitable conditions, 0.785 g of chromium is deposited on the cathode when 4370 C of electricity is passed into a chromium-containing electrolyte. Which of the following could have been the electrolyte?
 - A $CrCI_2$ C K_2CrO_3 B $CrCI_3$ D $K_2Cr_2O_7$
- **18** "Group II metals have higher melting points than the Group I metals."

A student suggested four possible reasons to explain the above statement. Which of these is most likely to be correct?

- A There is larger overlap of valence electrons between Group II metal atoms than Group I metal atoms.
- **B** Two valence electrons are available from each Group II metal atom for bonding the atom into the metallic lattice.
- **C** Group II metals have higher total ionization energies than Group I metals during formation of ions with octet electronic configuration.
- **D** Group II metal atoms have larger atomic radius than Group I metal atoms.
- **19.** Which statement is true about the chemistry of sodium bromide?
 - A It is a much weaker reducing agent than sodium chloride.
 - **B** It reacts with iron(III) chloride solution to form a pale green solution.
 - **C** It liberates a red-brown gas on warming with concentrated sulphuric acid.
 - **D** It is formed together with sodium bromate(I) when bromine is bubbled into hot concentrated sodium hydroxide.
- **20.** The standard enthalpy changes of formation of HC/ and HI are –92 kJ mol⁻¹ and +26 kJ mol⁻¹ respectively.

Which statement is most important in explaining this difference?

- A The bond energy of HI is smaller than the bond energy of HC/.
- **B** The bond energy of I_2 is smaller than the bond energy of CI_2 .
- **C** Chlorine is more electronegative than iodine.
- **D** The activation energy for the H_2 / Cl_2 reaction is much less than that for the H_2 / I_2 reaction.

21. The highest oxides of the elements sodium to sulfur are separately added to water. Which of the following diagrams best represents the pH of the solution produced?



22. Transition metals like platinum and rhodium are found in catalytic converters fitted into cars.

Which of the following statements best explains the role of transition metals in this use?

- A Transition metals can exhibit variable oxidation states in their compounds as 3d and 4s electrons have similar energies.
- **B** Transition metals form coloured ions due to absorption of energy in the visible light region to promote an electron from a lower to a higher energy 3d orbital.
- **C** Transition metals have very high melting points because both 3d and 4s electrons are involved in forming strong metallic bond.
- **D** Transition metals have available and partially filled 3d orbitals for adsorption of reactant molecules.

23. Which line on the graph shows the relationship between the number of carbon atoms in an alkane and the number of moles of oxygen gas needed for complete combustion of the alkane?



24. On combustion, 10 cm³ of the vapour of a hydrocarbon **P** produces 60 cm³ of CO₂ measured under similar conditions of temperature and pressure. When **P** reacts with hydrogen over platinum catalyst, a compound of relative formula mass 84 is formed. What is the formula of **P**?



25. Which of the following halides will react most rapidly with aqueous sodium hydroxide?

Α	(CH ₃) ₃ C-F	С	(CH ₃) ₃ C-Cl
В	(CH ₃) ₃ C-Br	D	(CH ₃) ₃ C-I

- **26.** Compound **Q** has the following properties.
 - It produces white fumes when PCl_5 is added.
 - It reacts with Na_2CO_3 to give rapid effervescence.
 - It does not react with Cu²⁺ in alkaline solution but gives an orange precipitate with 2,4–DNPH.
 - It results in the formation of green Cr^{3+} ions from an acidified solution of $Cr_2O_7^{2-}$ ions

Which one of the following could be Q?



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- **27.** In which of the following sequences does the value of pK_a increase continuously?
 - A CH₃CHCICOOH, CH₃CH₂COOH, CH₃COOH
 - **B** CH₃CHCICOOH, CH₂CICH₂COOH, CH₃CH₂COOH
 - C CH₃CH₂COOH, CH₃CHCICOOH, CH₃CHFCOOH
 - D CH₃CH₂COOH, CH₃CHFCOOH, CH₃CF₂COOH

28. A liquid **R** is sparingly soluble in water but dissolves readily in cold hydrochloric acid. Evaporation of this solution yields a crystalline solid.

Which of the following could be **R**?

- A C₆H₅COCH₃
- **B** $C_6H_5NH_2$
- $C C_6H_5CN$
- **D** C_6H_5OH
- **29.** Which of the following statements is **false**?
 - A Denaturation does not affect the primary structure of proteins which implies that there is no breakage of the peptide bonds.
 - **B** In an alpha helix, the amide carbonyl oxygen of an amino acid residue n is hydrogen bonded to the amide hydrogen of residue n+4.
 - **C** The formation of the peptide link between amino acids is irreversible.
 - **D** The quaternary structure only applies to proteins that contain two or more polypeptide chains.
- **30.** Gastrins are heptadecapeptide (**17** amino acid units) hormones that stimulate the secretion of gastric acid in the stomach of mammals. On hydrolysis of gastrins, the following four peptide fragments were isolated.

gly-trp leu-glu-glu-glu-glu-ala-ala-try glu-gly-pro-trp met-asp-phe

C-terminus analysis of the heptatdecapeptide yields a *phe* residue while N-terminus analysis yields a *glu* residue.

Based on the information above, suggest a primary structure for the heptatdecapeptide and the number of peptide bonds it contains.

	Primary Structure	No. of peptide bonds
Α	glu-gly-pro-trp-gly-trp-leu-glu-glu-glu-glu-ala-ala-try-met-asp-phe	17
В	glu-gly-pro-trp-gly-trp-leu-glu-glu-glu-glu-ala-ala-try-met-asp-phe	16
С	phe-asp-met-gly-trp-leu-glu-glu-glu-glu-ala-ala-try-trp-pro-gly-glu	16
D	phe-asp-met-gly-trp-leu-glu-glu-glu-glu-ala-ala-try-trp-pro-gly-glu	17

Section B

For questions 31 to 40 below, 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

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

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

31. For the reaction

 $2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$ $\Delta H = -98 \text{ kJ mol}^{-1}$

Which of the following conditions increase both the rate of reaction and yield of products?

- 1 Add a suitable catalyst and add a suitable solvent to dissolve SO₃.
- 2 Decrease the volume of the vessel.
- 3 Increase the temperature and decrease pressure
- **32.** A car burning lead-free fuel has a catalytic converter fitted to its exhaust. On analysis, its exhaust gases are shown to contain small quantities of nitrogen oxides.

Which modifications would result in lower exhaust concentrations of nitrogen oxides?

- 1 an increase in the surface area of the catalyst in the converter.
- 2 an increase in the rate of flow of the exhaust gases through the converter.
- **3** a much higher temperature of combustion in the engine
- **33.** The table below shows the pK_a values of some acids. Which of the following statement(s) about the acids is/are true?

Acid	pK _a
НСООН	3.8
CH₃COOH	4.8
HCN	9.3

- 1 HCOOH is the strongest acid
- 2 The K_a value for HCN is about 5 x 10⁻¹⁰ mol dm⁻³
- **3** The maximum buffer capacity for an acidic buffer containing CH₃COOH occurs at a pH of 4.8

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

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

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

- 34. Which of the following statement(s) is / are true about Group II elements, Ca, Sr and Ba?
 - 1 They are readily oxidised.
 - 2 The elements react with cold water to liberate hydrogen.
 - **3** Oxides of Group II elements are either basic or amphoteric.
- 35. Many drugs show optical isomerism. The diagrams show the structures of three drugs.



Amphetamine

Phenobarbital

Lidocaine

Which of these drugs are optically active?

- 1 Amphetamine
- 2 Phenobarbital
- 3 Lidocaine

36. Which of the following compounds are reduced by LiAlH₄?

- 1 benzoic acid
- 2 benzaldehyde
- 3 phenylmethanol

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

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

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

37. Hippuric acid has the following structure:



Which properties does it possess?

- 1 It can be hydrolysed to produce an amino acid.
- 2 It can be made by reacting benzoyl chloride with aminoethanoic acid.
- 3 It can be neutralised by reaction with cold aqueous sodium hydroxide.
- **38**. The structure of compound **A** is shown below.



What types of reactions will compound A undergo?

- 1 neutralisation
- 2 electrophilic substitution
- 3 nucleophilic substitution

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

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

No other combination of statements is used as a correct response

39. Which statements about methylamine, dimethylamine and trimethylamine are **incorrect**?

Compound	р <i>К</i> _ь
CH ₃ NH ₂	3.36
(CH ₃) ₂ NH	3.29
(CH ₃) ₃ N	4.28

- 1 They are trigonal planar with respect to the nitrogen atom.
- 2 They all form amides with ethanoyl chloride.
- 3 Trimethylamine is a weaker base than dimethylamine due to the steric hindrance which decreases the chances of protonation
- **40.** Serine is an amino acid commonly found in human body. Its structural formula is $CH_2OHCH(NH_2)CO_2H$.

Which of the following statements about serine are correct?

- 1 In a buffer solution of pH 9, serine is attracted towards the anode when a potential difference is applied.
- 2 In a polypeptide, the hydroxyl group of serine maintains the secondary structure by forming hydrogen bonds with polar R groups of other amino acid residues.
- **3** The zwitterionic form of serine is

H₃N-C-COO⁻

---End of Paper---

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