2013 MJC H1 Prelim Paper 1 QP and Answers

1 The polyoxometallate $W_{72}Mn_{12}Si_7O_{268}^{40-}$ was recently identified in a crystal garden.

Which row gives oxidation states of tungsten and manganese that are consistent with this formula?

	oxidation state of tungsten	oxidation state of manganese
Α	+3	+2
В	+3	+3
С	+6	+2
D	<mark>+6</mark>	<mark>+3</mark>

2 Copper (II) ions react with iodide ions to release iodine as shown in the following equation.

 $2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$

The iodine released can be determined by titration using a standardised solution of sodium thiosulfate. The equation for this reaction is shown below,

$$2S_2O_3^{2-}$$
 + $I_2 \rightarrow S_4O_6^{2-}$ + $2I^-$

25.00 cm³ of a solution containing copper (II) ions was treated with excess iodide ions. The resulting iodine required 26.50 cm³ of sodium thiosulfate of concentration 0.150 mol dm⁻³ for complete reaction.

What was the concentration of copper (II) ions in the solution used?

- **A** 0.0795 mol dm⁻³
- **B** 0.0912 mol dm⁻³

C 0.159 mol dm⁻³

D 0.318 mol dm⁻³

3 In a reaction, 0.20 mol of an oxide, N_xO_y was reacted with 20 dm³ of hydrogen gas at room temperature and pressure and passed over a heated catalyst. At the end of the reaction, 0.80 dm³ of hydrogen gas remained. The ammonia produced required 0.200 mol of sulphuric acid for complete neutralisation.

The reaction of the oxide with hydrogen can be represented by the following equation:

$$N_{x}O_{y}(g) + \frac{3x + 2y}{2} H_{2}(g) \rightarrow x NH_{3}(g) + y H_{2}O(I)$$

What is the molecular formula of the oxide?

 A
 NO

 B
 NO2

 C
 N2O

 D
 N2O4

- 4 Which compound is composed of a cation and anion(s) that do **not** contain the same number of electrons as each other?
 - A LiH
 - B NaOH
 - C NH₄F
 - D TiCl₃
- **5** The ionic radius of the elements in Period 3 (Na to C*l*) changes across the period.

Which of the following statements does **not** explain the trend of the ionic radius across the period?

- A Across the period, there is an increase in the nuclear charge.
- **B** The anions have greater shielding effect than the cations.
- **C** Screening effect is approximately constant among the cations.
- **D** The effective nuclear charge decreases from P^{3-} to CI.

- **6** Which of the following statements describe a phenomenon which **cannot** be explained by hydrogen bonding?
 - A Ice floats on water.
 - **B** The boiling point of methanol is lower than that of ethanol.
 - **C** Ethanal dissolves in water.
 - **D** Ethanoic acid molecules form dimers when dissolved in benzene.
- 7 A covalent molecule contains
 - 14 electrons,
 - one lone pair of electrons,
 - two π bonds.

What is the molecule?

A C₂H₄

B HCN

- H_2O_2
- **D** N₂
- **8** Titanium occurs naturally as the mineral rutile, TiO₂. One possible method of extraction of titanium is to reduce the rutile by heating with carbon.

 $TiO_2(s) + 2C(s) \rightarrow Ti(s) + 2CO(g) \qquad \Delta H = +720 \text{ kJ mol}^{-1}$

Given that the enthalpy change of formation of CO(g) is -110 kJ mol⁻¹, what is enthalpy change of formation of TiO₂(s)?

A -830 kJ mol⁻¹

B +830 kJ mol⁻¹

C -940 kJ mol⁻¹

D +940 kJ mol⁻¹

9 The curve **Y** and the value E_a represent the distribution of energies of the molecules and the activation energy for an uncatalysed gaseous reaction.



What is a possible outcome if the reaction is catalysed?

- A The distribution of energies will be given by curve **X** and the activation energy by value **V**.
- B The distribution of energies will be given by curve Y and the activation energy by value V.
- **C** The distribution of energies will be given by curve **Y** and the activation energy by value **W**.
- **D** The distribution of energies will be given by curve **Z** and the activation energy by value **W**.
- 10 Two moles of compound J were placed in a vessel. The compound J was partly decomposed by heating. A dynamic equilibrium between chemicals J, K and L was established.

At equilibrium, x mol of L were present and the total number of moles present was (2+x). What is the equation for this equilibrium?

 $A = J \Longrightarrow 2K + L$

B 2J ≕ 2K + L

- C 2J ⇒ K + L
- $\mathsf{D} \qquad \mathsf{2J} \rightleftharpoons \mathsf{K} + \mathsf{2L}$

11 Bromine is formed by the reaction between bromate(V) ions and bromide ions and acid:

$$BrO_{3}^{-}(aq) + 5Br^{-}(aq) + 6H^{+}(aq) \rightarrow 3Br_{2}(aq) + 3H_{2}O(l)$$

The results of some experiments on the reaction are shown below.

Exporimont	Concentration / mol dm ⁻³			Initial rate /
Experiment	BrO ₃ ⁻	Br⁻	H⁺	mol dm ⁻³ s ⁻¹
1	0.10	0.10	0.10	1.2 x 10 ⁻³
2	0.10	0.30	0.10	3.6 x 10 ⁻³
3	0.20	0.10	0.10	2.4 x 10 ⁻³
4	0.20	0.10	0.20	9.6 x 10 ⁻³

Which statement is true based on the above data?

- **A** The overall order of reaction is three.
- **B** The rate of reaction is independent of $[BrO_3]$.
- **C** The unit of the rate constant is mol⁻³ dm⁹ s⁻¹.
- **D** The time taken for the concentration of Br⁻ to decrease to half its initial value is the same for Experiment 1 to 4.
- 12 Citric acid is a monobasic acid.

Which of the following pair of solutions, when mixed at equal volume, will give a best buffer solution that resists a pH change when a small amount of acid or base is added?

- A 0.5 mol dm⁻³ of citric acid and 0.5 mol dm⁻³ of NaOH
- **B** 0.5 mol dm⁻³ citric acid and 0.125 mol dm⁻³ of Ba(OH)₂
- **C** 1.0 mol dm⁻³ sodium citrate and 0.25 mol dm⁻³ of H_2SO_4
- **D** 1.0 mol dm⁻³ sodium citrate and 0.5 mol dm⁻³ of H_2SO_4

13 A dilute solution of hydrogen peroxide decomposes slowly in aqueous solution according to the following equation:

$$2H_2O_2(aq) \rightarrow 2H_2O(\mathit{l}) + O_2(g)$$

A solution with an original concentration of 3.00 mol dm⁻³ was placed in a bottle contaminated with transition metal ions, which act as catalyst for the decomposition. The rate of decomposition was measured by withdrawing 10.0 cm³ portion at various times and titrating with acidified 0.05 mol dm⁻³ KMnO₄(aq).

The following results were obtained.



Volume of KMnO₄(aq) / cm³

How long has the solution in the bottle been contaminated before the first portion was withdrawn for titration? Assume that 5 mol H_2O_2 reacts with 2 mol KMnO₄.

- **A** 14 minutes
- B 42 minutes
- **C** 84 minutes
- **D** 112 minutes

- **14** Which of the following statement is correct for the sequence of compounds below considered from left to right?
 - NaF MgO A/N SiC
 - A The bonding becomes decreasingly covalent.
 - **B** The formula-units of these compounds are not isoelectronic.
 - C Electronegativity difference between the elements in each compound decreases.
 - **D** When water is added to these compounds, the resultant solution becomes increasingly acidic.
- **15** An element **X** in Period 3 is a metalloid and semiconductor and has a chloride which reacts with water to form an acidic solution.

An element **Y** has an atomic number one **less** than element **X**.

What is a property of the oxide of element Y?

- **A** It is a gas at room temperature.
- B It is amphoteric.
- **C** It is covalent.
- **D** Its formula is **Y**O₂.
- **16** The information relates to element **Z**.
 - Z is in Period 3 of the Periodic Table.
 - Z has a lower electrical conductivity than Mg.
 - A Z atom has half-filled subshell in its ground state.
 - Z forms an acidic oxide on exposure to air.

What is **Z**?

Α	Na
В	Si
C	P
D	Cl

17 Ethoxyethane, $C_2H_5OC_2H_5$, is the most well known of a class of compounds called ethers. Ethers have the general formula R_1-O-R_2 where R_1 and R_2 are hydrocarbon groups.

How many structural isomers does ethoxyethane have?

Α	2
В	3
С	6
D	7

18 Cholesterol is the most common steroid alcohol. It has a molecular formula of $C_{27}H_{46}O$ and has the structure shown.



How many carbon atoms are in the hydrocarbon group R?



19

Experiments are carried out on three compounds X, Y, and Z.



A sample of 0.01 mol of each compound is heated under reflux with 100 cm³ of 0.5 mol dm⁻³ NaOH (in excess) until hydrolysis is complete and any ammonia produced is expelled from solution. The excess NaOH is then titrated in each case and is found to require 40 cm³, 60 cm³ and 80 cm³ of 0.5 mol dm⁻³ HC/ for neutralisation.

	<u>40 cm³</u>	<u>60 cm³</u>	<u>80 cm³</u>
A	×	Y	Z
В	X	Z	Y
С	Y	X	Z
D	z	Y	х

20 1 mole of an organic compound **E** undergoes elimination on reaction with ethanolic sodium hydroxide to form 2 moles of HBr.





21 Compound **M** has the structural formula as shown below.



Compound M

Which of the following statement regarding M is correct?

A 1 mole of M reacts with hot dilute HC¹ to produce 2 moles of carboxylic acid.

- **B** M reacts with 2,4-dinitrophenylhydrazine give an orange precipitate.
- **C M** reacts with I₂ in NaOH to produce a yellow precipitate.
- **D M** is a product of an addition reaction.
- 22 The diagram shows a reaction scheme.



Which statement about this reaction scheme is not correct?

- A Step 1 involves addition.
- **B** Step 2 involves hydrolysis.
- **C P** forms a yellow precipitate with alkaline aqueous iodine.
- **D P** has the molecular formula $C_3H_4O_4$.

23 Terephthalaldehyde is used as an intermediate for manufacturing of dyes and fluorescent whitening agents. It can be synthesised from 4-methylbenzoic acid via a 3-step synthesis.



4-methylbenzoic acid

Terephthalaldehyde

Which of the following are the reagents and conditions needed for the conversion?

	Step 1	Step 2	Step 3
Α	$Cr_2O_7^2$ /H ⁺ , heat to distill	LiA/H ₄ , r.t.p	Hot KMnO₄/H⁺
В	$Cr_2O_7^{2-}/H^+$, heat to distill	NaBH ₄ , r.t.p	Hot KMnO₄/H⁺
С	<mark>Hot KMnO₄/H⁺</mark>	<mark>LiA/H₄, r.t.p</mark>	Cr ₂ O ₇ ²⁻ /H ⁺ , heat to distill
D	Hot KMnO₄/H⁺	NaBH ₄ , r.t.p	$Cr_2O_7^{2-}/H^+$, heat to distill

24 An industrial preparation of alcohols involves the following step.



What is the likely structure of compound **X** produced by the reaction below? $(D = {}^{2}_{1}H)$

$$\begin{array}{c} H \\ C = C \\ H_{3}C \\ H \end{array} + CO + D_{2} \\ \hline catalyst \\ C \\ H \\ \end{array} \rightarrow X$$



25 Sucrose is highly soluble, as shown in the graph, and it dissolves according to

 $C_{12}H_{22}O_{11}(s) \Longrightarrow C_{12}H_{22}O_{11}(aq)$ $\Delta H = +4.75 \text{ kJ mol}^{-1}$



A cup of coffee was made with 200 cm^3 of water at 80°C and as much sugar as would dissolve. It was left to cool to 60°C.

Sucrose Solubility

During cooling from 80°C to 60°C,

- **A** the fraction of $[C_{12}H_{22}O_{11}(aq)]/[C_{12}H_{22}O_{11}(s)]$ remains unchanged.
- **B** the system responds to the change in temperature by absorbing more heat.
- **C** the rate of forward reaction increases as the system can release heat more easily.
- **D** the position of equilibrium shifts left as it is an endothermic reaction.
- 26 Most elements contain more than one isotope, atoms that have the same chemical properties but different masses.

Which expressions correctly define the term *relative atomic mass* of an element?

- 1 The mass of 1 mole of atoms of an element relative to the mass of 1 mole of ¹²C atoms.
- 2 The mass of 1 atom of an element relative to the mass of 1 atom of ¹²C.
- **3** The mass of 1 mole of atoms of an element divided by 6.02×10^{23} .
- **27** Given that,

 $(CH_3)_3N + CH_3COOH \Longrightarrow (CH_3)_3NH^+ + CH_3COO^-$

Which of the following statements are **not** correct?

- 1 CH₃COOH acts as a Bronsted acid.
- 2 $(CH_3)_3N$ is the conjugate base of CH_3COOH .
- **3** $(CH_3)_3N$ and CH_3COOH can act as a buffer pair to resist pH changes.
- 28 Hydrogen reacts with gaseous bromine to form hydrogen bromide,

 $H_2(g) + Br_2(g) \longrightarrow 2HBr(g)$

and with gaseous iodine to form hydrogen iodide

 $H_2(g) + I_2(g) \longrightarrow 2HI(g)$

For the first reaction, the rate equation is

rate =
$$\frac{k_1[H_2][Br_2]^{1.5}}{[Br_2]k_2[HBr]}$$

For the second reaction, the rate equation is

rate =
$$k[H_2][I_2]$$

What can be deduced from this information only?

- 1 For the hydrogen/ bromine reaction, the formation of HBr slows down the rate of the forward reaction.
- 2 Only the hydrogen/ iodine reaction could be a single step reaction.
- **3** The overall order of reaction for the hydrogen/ bromine reaction is 2.

29 Compound X has the following structure.



Which of the following statements about Compound X are incorrect?

- Compound X reacts with 2,4-dinitrophenylhydrazine to form an orange precipitate.
- 2 One mole of Compound X completely reacts with three moles of Na₂CO₃.
- 3 One mole of Compound X completely reacts with three moles of KOH at room temperature and pressure.
- 30 Which pair of organic compounds **cannot** be distinguished by a chemical test?



2

