

## VICTORIA JUNIOR COLLEGE JC 2 PRELIMINARY EXAMINATION Higher 2

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# CHEMISTRY

### 9729//01

Paper 1 Multiple Choice

23 September 2021

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 index number, name and CT group on the Answer Sheet.

There are **thirty** questions. 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 booklet.

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

This document consists of **15** printed pages and **1** blank page.

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

**1** Use of the Data Booklet is relevant to this question.

The ion  $X^{2+}$  has 53 electrons and 78 neutrons.

Which of the following statements are incorrect?

- **1 X** atom is isoelectronic with Xe.
- 2 The fluoride of **X** is expected to have a higher melting point than RbF.
- 3 The first ionisation energy of element **X** is lower than that of Fr.
- 4 In an electric field, the ion  $X^{2+}$  will be deflected at a smaller angle than that of Na<sup>+</sup>.
- A 1, 2 and 3 C 2 and 4 only
- B1 and 4 onlyD3 only
- **2** To produce decaffeinated coffee, the ethanol–CO<sub>2</sub> mixture is used to extract caffeine from coffee beans.



caffeine

Which statement about caffeine is incorrect?

- A Caffeine is more soluble in the ethanol–CO<sub>2</sub> mixture due to the hydrogen bond formed between ethanol and caffeine.
- **B** Caffeine molecule has a planar structure.
- **C** There are altogether 25 sigma bonds and 4 pi bonds in a caffeine molecule.
- **D** There are 5 carbon atoms which are  $sp^2$  hybridised.

3 In which pair does compound **X** have a higher boiling point than compound **Y**?

	compound X	compound Y
Α	CH <sub>3</sub> CO <sub>2</sub> NH <sub>4</sub>	$CH_3CH_2NH_2$
В	SiCl <sub>4</sub>	SiO <sub>2</sub>
С	PH <sub>3</sub>	SiC <i>l</i> ₃H
D	Ni(OH) <sub>2</sub>	NiSO <sub>4</sub>
	. ,	

**4** A vessel is made of an air-filled plastic and has a volume of 40.0 cm<sup>3</sup>.

At 27 °C and 52.8 kPa, a slightly dented vessel of volume 38.5 cm<sup>3</sup> is filled with air. To restore its original shape, the air inside the dented vessel is heated to a temperature of 60 °C. The pressure of air inside the vessel increases and creates a uniform outward force.

Assuming that the air inside the vessel behaves ideally, what is the pressure of air inside the vessel at 60  $^{\circ}$ C when the shape is restored?

Α	56.4 kPa	С	226 kPa
В	113 kPa	D	244 kPa

5 Elements Y and Z can be found in the third period of the Periodic Table.

Two solutions were prepared by dissolving a chloride of **Y** and an oxide of **Z** in separate portions of water. Both solutions prepared can be used to dissolve  $Al_2O_3$  but only one can be used to dissolve  $SiO_2$ .

What could **Y** and **Z** be?

	Y	Z	
Α	silicon	phosphorus	
В	phosphorus	sodium	
С	magnesium	phosphorus	
D	sodium	sulfur	

**6** The diagram represents the melting points of four consecutive elements in the third period of the Periodic Table.



The sketches below represent another two properties of the elements.



What could properties X and Y be?

	property <b>X</b>	property Y	
Α	ionic radius	effective nucleus charge	
в	atomic radius	electrical conductivity	
С	number of valence electrons	boiling point	
D	electronegativity	third ionisation energy	

7 Use of the *Data Booklet* is relevant to this question.

Which statement about Group 2 elements and their compounds is correct?

- **A** BaC $l_2$  solution has a lower pH than that of MgC $l_2$  solution.
- **B** The volume of gases formed per gram of carbonate decomposed increases down the group.
- **C** Strontium reacts more vigorously with cold water than magnesium since the standard reduction potential of strontium is more negative than that of magnesium.
- **D** Barium sulfate occurs naturally as a solid ore while magnesium sulfate occurs mainly in solution since barium sulfate has a strong crystalline lattice.
- 8  $X_2$ ,  $Y_2$  and  $Z_2$  are  $Cl_2$ ,  $Br_2$  and  $I_2$  but not necessarily in the given order.

The table below recorded observations when these halogens are separately added to aqueous solutions containing the halide ions followed by the addition of an organic solvent,  $CCl_4$ .

experiment	reactants	observation after shaking with CCl <sub>4</sub>	
1	<b>X</b> ₂ (aq) + <b>Y</b> ⁻ (aq)	Violet organic layer seen.	
2	<b>Z</b> <sub>2</sub> (aq) + <b>X</b> <sup>-</sup> (aq)	Orange-red organic layer seen.	
3	<b>Z</b> ₂ (aq) + <b>Y</b> ⁻ (aq)	Violet organic layer seen.	
4	<b>Y</b> <sub>2</sub> (aq) + <b>X</b> <sup>-</sup> (aq)	(Observations not recorded)	

Which information could be deduced from the above experiments?

- **A HY** has a lower boiling point that **HX**.
- **B** Ag**Y**(s) is soluble in excess dilute aqueous ammonia.
- **C**  $K_{\rm a}$  value of H**Z** is larger than that of H**Y**.
- **D** The colour of the organic layer in experiments **3** and **4** is the same.

**9** Sodium percarbonate,  $(Na_2CO_3)_{x.y}(H_2O_2)$  is a compound with both reducing and oxidising properties. It is present in some home and laundry cleaning products.

10.0 cm<sup>3</sup> of 0.100 mol dm<sup>-3</sup> sodium percarbonate releases 48.0 cm<sup>3</sup> of carbon dioxide at room conditions on reaction with excess aqueous sulfuric acid.

An identical sample, on titration with 0.0500 mol  $dm^{-3}$  KMnO<sub>4</sub> in acidic medium, required 24.0 cm<sup>3</sup> before the first pink colour appears.

What is the ratio $\frac{y}{x}$ ?			
Α	<u>1</u> 3	С	<u>3</u> 2
В	<u>2</u> 3	D	<u>3</u> 1

**10** A flammable compound, with the formula  $CS_z$ , burns in oxygen to give  $CO_2$  and  $SO_2$  as the only products.

In a particular experiment, 20 cm<sup>3</sup> of  $CS_z$  vapour was completely reacted with 80 cm<sup>3</sup> of oxygen. The volume of the gaseous mixture obtained after combustion was treated with excess aqueous sodium hydroxide. The volume of the gaseous mixture decreased to 20 cm<sup>3</sup> after the treatment with sodium hydroxide.

All measurements of volume were made at the same temperature and pressure, conditions under which  $CS_z$  is a gas.

What is the value of *z*?

Α	1	C	3
в	2	D	4

**11** The enthalpy change of the following reaction between carbon and chromium(III) oxide is given:

 $3C(s) + Cr_2O_3(s) \rightarrow 2Cr(s) + 3CO(g)$   $\Delta H_r^{\Theta} = +790 \text{ kJ mol}^{-1}$ 

In addition to  $\Delta H_r^{e}$ , one or more of the enthalpy changes listed below need to be known in order to calculate the enthalpy change of formation of Cr<sub>2</sub>O<sub>3</sub>.

- 1 enthalpy change of combustion of C
- 2 enthalpy change of atomisation of Cr
- 3 sum of the 1st, 2nd and 3rd ionisation energies of Cr
- 4 enthalpy change of combustion of CO

Which are the enthalpy changes that need to be known?

Α	1, 2 and 3 only	С	3 and 4 only
В	1 and 4 only	D	<b>4</b> only

**12** Instant 'cold packs' are used to relieve pain in athletes and footballers due to pulled muscles and sprained joints. They are composed of powdered ammonium nitrate and water separated by a thin plastic membrane. When the pack is squeezed, the membrane breaks and ammonium nitrate dissolves in water according to the equation below:

 $NH_4NO_3(s) + nH_2O(l) \rightarrow NH_4NO_3(aq)$ 

Which statement about the above reaction is correct?

- **A** It is spontaneous at all temperatures.
- **B** It is not spontaneous at any temperature.
- **C** It is more spontaneous at lower temperatures.
- **D** It is more spontaneous at higher temperatures.

**13** Hydrogen reacts with gaseous bromine to form hydrogen bromide:

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

It also reacts with gaseous iodine to form hydrogen iodide:

$$H_2(g) + \operatorname{I}_2(g) \to 2HI(g)$$

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<sub>2</sub>][I<sub>2</sub>]

 $k_1$ ,  $k_2$  and k represent rate constants.

What can be deduced based on this information only?

- 1 The mechanism of the hydrogen / bromine reaction involves free radicals.
- 2 Only the hydrogen / iodine reaction could be a single-step reaction.
- **3** For the hydrogen / bromine reaction, the formation of HBr slows down the rate of the forward reaction.

Α	1, 2 and 3	С	2 and 3 only
В	1 and 2 only	D	3 only

**14** The age of rock samples can be calculated using Uranium-Lead dating. <sup>235</sup>U is an unstable isotope which decays into <sup>207</sup>Pb. This nuclear reaction obeys first-order kinetics with a half-life of 710 million years.

The decay can be summarised by the following equation:

 $^{235}U \rightarrow ^{207}Pb$  + other decay products

A rock sample has a  $^{235}$ U :  $^{207}$ Pb ratio of 1 : 15.

Assuming that all the <sup>207</sup>Pb detected is formed from the decay of <sup>235</sup>U, what is the age of the rock sample?

- A 710 million years C 2130 million years
- **B** 1420 million years **D** 2840 million years

15 Consider the equilibrium below:

$$P(g) + Q(g) \rightleftharpoons 2R(g)$$
  $K_c = 0.16 \text{ at } 700 \text{ K}$ 

A certain amount of **R** is placed in a sealed vessel and allowed to reach equilibrium at 700 K. The composition of the equilibrium mixture is as follows:

substance	amount / mol	
Р	0.50	
Q	0.50	
R	0.20	

0.10 mol of  $\mathbf{R}$  is then added to the equilibrium mixture.

What will be the amount of R present when the new equilibrium is established?

Α	0.22	С	0.30
В	0.27	D	0.37

**16** At a body temperature of 37 °C,  $K_w$  has a value of 2.4 × 10<sup>-14</sup>.

What is the concentration of OH<sup>-</sup> if the pH of blood is 7.4 under these conditions?

Α	$3.98 \times 10^{-8}  mol  dm^{-3}$	С	$6.03 \times 10^{-7} \text{ mol dm}^{-3}$
В	$2.52 \times 10^{-7} \text{ mol dm}^{-3}$	D	$7.00 \times 10^{-7} \text{ mol dm}^{-3}$

A sample of 1 mol of ethanoic acid is diluted at constant temperature to a volume *V*.A graph is shown below, where the *x*-variable is *V*:



Which quantities could the y-variable be?

- 1 fraction of ethanoic acid that has dissociated
- 2 pH of ethanoic acid solution
- 3 *K*<sub>a</sub> of ethanoic acid

Α	1, 2 and 3	С	2 and 3 only
В	<b>1</b> and <b>2</b> only	D	1 only

**18** The sparingly soluble salt,  $Zn_3[Fe(CN)_6]_2$ , consists of the cation  $Zn^{2+}$  and the anion  $[Fe(CN)_6]^{3-}$ .

Given that the  $K_{sp}$  value for the salt is **W**, what is the concentration of the anion when the salt dissociates to form a saturated solution at equilibrium?

Α	$\sqrt[3]{\frac{W}{108}}$	C	$\sqrt[3]{\frac{8W}{27}}$
В	$\sqrt[5]{\frac{W}{108}}$	D	5√ <mark>8₩</mark> √27

**19** The Wittig reaction offers a highly versatile method to synthesise a wide variety of alkenes.

The mechanism for the reaction is summarised below.



(Ph denotes a phenyl group, C<sub>6</sub>H<sub>5</sub>-)

Which types of reaction have occurred in the mechanism?

- 1 neutralisation
- 2 condensation
- 3 nucleophilic substitution
- A 1, 2 and 3 C 2 and 3 only
- **B** 1 and 2 only

3 only

**20** There are six possible constitutional (structural) isomers for an organic compound with molecular formula  $C_4H_8O_2$ .

D

Which of the following is incorrectly named as one of the six isomers?

- A methyl propanoate
- **B** propyl methanoate
- **C** 1-methylethyl methanoate
- **D** 2-methylethyl methanoate

**21** The dehydration of propan–2–ol to form propene is thought to involve the following steps.

Which of the following statements are incorrect?

- 1 Aqueous  $H_2SO_4$  is used as a reagent in this reaction.
- 2 It is more likely for primary alcohols to proceed via this mechanism than tertiary alcohols.
- **3** A possible side product of the reaction is CH<sub>3</sub>CH(OSO<sub>3</sub>H)CH<sub>3</sub>.

Α	1, 2 and 3	С	1 and 3 only
В	1 and 2 only	D	2 and 3 only

**22** The structure of 2-methylbutane-1,2,3,4-tetrol of molecular formula  $C_5H_{12}O_4$  is as shown.



After prolonged heating under reflux with an excess of acidified potassium dichromate(VI), it forms a compound **X** which also has five carbon atoms.

What is the molecular formula of compound **X**?

**A**  $C_5H_{10}O_5$  **B**  $C_5H_{18}O_5$  **C**  $C_5H_8O_6$  **D**  $C_5H_6O_6$ 

**23** Which set of reagents and conditions **cannot** be used for the interconversion of compounds shown in the reaction scheme below?



- A Heat with excess concentrated H<sub>2</sub>SO<sub>4</sub>
- **B** Add cold concentrated H<sub>2</sub>SO<sub>4</sub>, followed by water with heating
- **C** Heat with aqueous NaOH
- **D** Heat with alcoholic KOH
- 24 Which synthetic route will lead to a successful preparation of the following product?



**25** A student synthesised the following compound in the laboratory and wrote four statements about this compound.



Which statement is incorrect?

- **A** On heating with acidified  $K_2Cr_2O_7(aq)$ , the colour of the solution turns green.
- **B** On warming with 2,4-dinitrophenylhydrazine, no orange crystals will be formed.
- **C** On heating with alkaline aqueous iodine, a pale yellow precipitate will be formed.
- **D** On adding Br<sub>2</sub>(aq), one bromine atom will be incorporated into the compound to form the major product.
- **26** An organic compound,  $C_{10}H_{11}NO_2$  has the following physical and chemical properties:
  - It gives a brick red precipitate when warmed with Fehling's solution.
  - It gives a purple colouration when warmed with neutral FeCl<sub>3</sub>(aq).
  - It is moderately soluble in water.

Which is a possible structure of this compound?



- 27 Which option shows the given ions arranged in order of increasing  $pK_a$  values?
  - **A**  $NH_4^+$ ,  $C_6H_5NH_3^+$ ,  $(CH_3CH_2)_2NH_2^+$
  - **B**  $(CH_3CH_2)_2NH_2^+, C_6H_5NH_3^+, NH_4^+$
  - **C**  $C_6H_5NH_3^+$ ,  $NH_4^+$ ,  $(CH_3CH_2)_2NH_2^+$
  - **D**  $(CH_3CH_2)_2NH_2^+, NH_4^+, C_6H_5NH_3^+$

**28** Amines react with carboxylic acids to form amides in the presence of the solvent dicyclohexylcarbodiimide, DCC, at room temperature.

![](_page_13_Figure_1.jpeg)

Which synthetic route converts compound **A** to compound **B** with the greatest increase in relative molecular mass?

compound  $\mathbf{A} \xrightarrow{\mathbf{I}} \mathbf{E} \xrightarrow{\mathbf{II}}$  compound  $\mathbf{B}$ 

Compound A Ι Π Α Heat with K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> in CH<sub>3</sub>NH<sub>2</sub> in DCC O Ο solvent at room  $H_2SO_4(aq)$ temperature ĊН В CH<sub>3</sub>NH<sub>2</sub> in DCC Heat with K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> in 0 solvent at room  $H_2SO_4(aq)$ temperature ÓН С Heat with K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> in CH<sub>3</sub>NH<sub>2</sub> in DCC solvent at room  $H_2SO_4(aq)$ temperature  $\cap$  $\cap$ ÓН D CH<sub>3</sub>NH<sub>2</sub> in DCC Heat with K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> in solvent at room  $H_2SO_4(aq)$ temperature Ο 0^ OH

29 Three metals X, Y and Z, are connected in pairs in two electrochemical cells as shown below.

![](_page_14_Figure_1.jpeg)

Which statements are correct?

- **1 Z** is the weakest reducing agent.
- 2  $Y^{2+}(aq)$  can oxidise both X and Z.
- 3  $E_{cell}$  is +0.78 V when the two half-cells of  $\mathbf{Y}^{2+}(aq)|\mathbf{Y}(s)$  and  $\mathbf{Z}^{2+}(aq)|\mathbf{Z}(s)$  are connected together.
- **4** Adding water to  $X^{2+}(aq)|X(s)$  half–cell will decrease and increase the  $E_{cell}$  of electrochemical cell 1 and 2 respectively.

Α	1, 3 and 4 only	С	2 and 3 only
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- **B** 1 and 4 only **D** 2 only
- **30** A current of 3.0 A is used to plate a copper metal piece from 500 cm<sup>3</sup> aqueous CuSO<sub>4</sub>. The concentration of aqueous CuSO<sub>4</sub> after 2.0 hours drops to 0.776 mol dm<sup>-3</sup>.

What is the initial concentration of aqueous CuSO<sub>4</sub>?

- A 0.614 mol dm<sup>-3</sup>
- **B** 0.684 mol dm<sup>-3</sup>
- **C** 1.00 mol dm<sup>-3</sup>
- **D** 1.11 mol dm<sup>-3</sup>

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