Candidate Name:

# 2022 End-of-Year Examination Pre-University 1

## **H2 CHEMISTRY**

Paper 1 Multiple Choice & Structured Questions

Additional materials: Multiple Choice Answer Sheet Data Booklet

## **READ THESE INSTRUCTIONS FIRST**

Do not turn over this question paper until you are told to do so

Write your name, class and admission number on all the work you hand in.

For Section A, there are fifteen 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 Multiple Choice Answer Sheet provided. Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Read the instructions on the Multiple Choice Answer Sheet very carefully.

For Section B, write in dark blue or black pen. You may use an HB pencil for any diagrams or graphs. Do not use staples, paper clips, glue or correction fluid. Answer all the questions. The use of an approved scientific calculator is expected, where appropriate. Any rough working should be done in this question paper.

Question	Section A	Section B					Total	
Question	Section A	1	2	3	4	5	6	TOLAT
Marks	15	10	12	10	8	9	6	70





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12 Oct 2022

2 hours

#### Section A – Multiple Choice

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

1 How many subshells and orbitals are there in principal quantum shell number 3?

	subshells	orbitals
Α	2	4
В	2	6
С	3	6
D	3	9

Use of the Data Booklet is relevant to this question.The following are flight paths of charged particles when accelerated in an electric field.



Which correctly identifies S, T and U?

	S	Т	U
Α	<sup>14</sup> N+	<sup>14</sup> C <sup>-</sup>	<sup>14</sup> C <sup>2–</sup>
В	<sup>14</sup> N <sup>-</sup>	<sup>12</sup> C <sup>+</sup>	<sup>12</sup> C <sup>2+</sup>
С	<sup>12</sup> C <sup>-</sup>	<sup>14</sup> N <sup>2+</sup>	<sup>14</sup> N <sup>+</sup>
D	<sup>14</sup> C <sup>-</sup>	<sup>12</sup> C <sup>+</sup>	<sup>14</sup> N <sup>+</sup>

- In microwave ovens, the energy produced is absorbed by polar molecules.Which of the following would absorb microwave energy?
  - 1 CO<sub>2</sub>
  - 2 BrF<sub>3</sub>
  - 3 BF<sub>3</sub>
  - 4 SO<sub>2</sub>

Α

1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 2 and 4 only

- 4 Which of the following **cannot** be explained by hydrogen bonding?
  - A difference in boiling point between ethanol and hexan-1-ol
  - **B** difference in melting point between H<sub>2</sub>O and HF
  - C higher than expected relative molecular mass of ethanoic acid in benzene
  - D difference in density between water and ice
- **5** Trifluorooxonium has the formula  $OF_3^{n+}$  and its shape is trigonal pyramidal. What is the value of *n* in trifluorooxonium?
  - **A** 1 **B** 2 **C** 3 **D** 4
- 6 Histamine is produced in the body to help fight infection. Its shape allows it to fit into receptors which expand blood vessels.



histamine

What are the values of the bond angles **x**, **y** and **z**?

	x	У	z
Α	120°	90°	120°
В	109°	109°	107°
С	107°	109°	120°
D	107°	120°	109°

**7** Two bulbs **R** and **S**, containing Ne and Ar respectively, are connected to a 9 dm<sup>3</sup> vacuum chamber as shown.



What will be the total pressure in the vessel when the valves are opened at constant temperature?

- A 168 kPa B 317 kPa C 356 kPa D 375 kPa
- 8 In which reactions does NH<sub>3</sub> behave as a Brønsted-Lowry acid?

1 
$$HSO_4^- + NH_3 \rightarrow SO_4^{2-} + NH_4^+$$
  
2  $Ag^+ + 2NH_3 \rightarrow [Ag(NH_3)_2]^+$   
3  $NH_3 + PO_4^{3-} \rightarrow NH_2^- + HPO_4^{2-}$   
**A** 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only

9 Which of the following correctly defines the term *relative atomic mass* of an element?

- A the mass of 1 atom of an element relative to the mass of 1 atom of <sup>12</sup>C
- **B** the mass of 1 mole of atoms of an element divided by 6.02 x 10<sup>23</sup>
- **C** the mass of 1 mole of atoms of an element relative to  $\frac{1}{12}$  the mass of 1 atom of  ${}^{12}$ C
- **D** the mass of 1 mole of atoms of an element relative to  $\frac{1}{12}$  the mass of 1 mole of <sup>12</sup>C atoms

D

3 only

A carbon sample contains a mixture of <sup>12</sup>C and <sup>14</sup>C isotopes. When 1.000 g of this sample is burned completely in <sup>16</sup>O<sub>2</sub>, the mass of CO<sub>2</sub> formed is 3.55 g.
 What is the percentage by mass of the <sup>12</sup>C isotope in this sample?

Α	12.4%	В	30.6%	С	50.5%	D	69.4%
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11 An ion of metal M can be oxidised by potassium manganate(VII) in acid solution to form MO<sub>3</sub><sup>-</sup>. In an experiment, 0.00500 mol of the ion of M required 15.0 cm<sup>3</sup> of 0.200 mol dm<sup>-3</sup> potassium manganate(VII) for complete reaction.

What is the initial oxidation state of the ion of **M** given that potassium manganate(VII) is reduced to  $Mn^{2+}$ ?

**A** +1 **B** +2 **C** +4 **D** +7

Use of the Data Booklet is relevant to this question.
 When 0.85 g of ethanol (M<sub>r</sub> = 46.0) was burnt completely under a container containing 350 g of water, the temperature of the water rises by 10 °C.
 The enthalpy change of combustion of ethanol is –1367 kJ mol<sup>-1</sup>.
 What is the efficiency of this reaction?

- **A** 6.10% **B** 42.1% **C** 57.9% **D** 93.9%
- 13 In cars, internal combustion engines convert the chemical energy in fuels into kinetic energy.The following reaction takes place in an internal combustion engine.

 $2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$ 

Which of the following statements are correct about the reaction?

- 1 Enthalpy change of the reaction is negative.
- 2 Entropy change of the reaction is negative.
- 3 The reaction is spontaneous at all temperatures.
- A 1 and 2 only B 1 and 3 only C 2 and 3 only D 3 only

14 Which of the following processes is always endothermic?

- **A** dimerisation of AlCl<sub>3</sub>
- B melting of iron bar
- C neutralisation between aqueous acid and aqueous alkali
- D condensation of water

15 How many chiral carbon atoms are present in a molecule of vitamin C?



#### **END OF SECTION A**

#### Section B – Structured Questions

Answer all questions.

- 1 Magnesium ethanedioate, MgC<sub>2</sub>O<sub>4</sub>, is an ionic solid present in mineral supplements to treat magnesium deficiency.
  - (a) (i) Given that there is a plane of symmetry in the structure of ethanedioate ion, draw a 'dot-and-cross' diagram to illustrate the bonding in ethanedioate ion.
     Hence state the shape about each carbon atom.

(ii) Ethanedioate ion reacts with hydrochloric acid in a mole ratio of 1 : 1 in an acid-base reaction.

Explain why ethanedioate ion can be described as a Brønsted-Lowry base in this reaction and state the formula of its conjugate acid.

.....[2]

Hydrated salt of magnesium ethanedioate has the formula MgC<sub>2</sub>O<sub>4</sub> • xH<sub>2</sub>O, where x is an integer. When 7.415 g of hydrated magnesium ethanedioate is heated strongly, it decomposes to form a white alkaline solid **P** and three gases **Q**, **R** and H<sub>2</sub>O(g). The molecular mass of **P** is 40.3 g mol<sup>-1</sup>.

When the gases are passed through anhydrous calcium chloride,  $H_2O(g)$  is completely absorbed and the mass of the calcium chloride increases by 1.800 g.

When the remaining gases,  $\mathbf{Q}$  and  $\mathbf{R}$ , are subsequently passed through aqueous potassium hydroxide, only  $\mathbf{Q}$  reacts with potassium hydroxide.

Gas R is a poisonous gas. It reacts with oxygen gas to give gas Q.

(b) Suggest the chemical formula of **P**, **Q**, **R** and **S** respectively.

 (c) Hence write a balanced chemical equation for the decomposition of  $MgC_2O_4 \cdot xH_2O$ . You may use *x* to balance the equation.

.....[1]

(d) Determine the value of x in  $MgC_2O_4 \cdot xH_2O$ , showing your working clearly.

[3] [Total: 10] 2 A methane fuel cell converts the chemical energy of methane and oxygen into electricity.Figure 2.1 shows a simplified diagram of a methane fuel cell.





In the fuel cell where the electrolyte is an acid, methane is oxidised to carbon dioxide while oxygen gas in air is reduced to water.

(a) By determining the oxidation number of carbon atom in methane and carbon dioxide respectively, explain why the production of carbon dioxide from methane is an oxidation reaction.

	••
	 11
o) Write the half equation for the oxidation of methane.	.1
	1]
c) Using your answer in (b) and a relevant half equation obtained from the <i>Data Booklet</i> , wri a balanced equation for the reaction taking place in the fuel cell.	te
[	1]

(d) Using bond energy values from the *Data Booklet*, calculate the enthalpy change for the reaction represented in (c).

(e) The actual value for the standard enthalpy change of the reaction in (c) is likely to be different from your answer in (d).
 Suggest two reasons why there is a discrepancy between the actual value and the value calculated in (d).

(f) Given that the standard entropy change of the reaction in (c) is -241 J K<sup>-1</sup> mol<sup>-1</sup>, use your answer in (d) to calculate the maximum temperature at which the reaction would be spontaneous.

[2]

(g) Hence on the axes below, sketch a graph of ∆G<sup>⊕</sup>, in kJ mol<sup>-1</sup>, against T, in K. In your sketch, show clearly the values of the x-intercept and y-intercept, and suggest the value of the gradient.



3 (a) Figure 3.1 shows the first ionisation energies of the elements sodium to potassium.





For each of the pairs of elements listed below, explain the difference between the values of their first ionisation energies.

(i)	Na and K	
		[2]
(ii)	Mg and Al	
		[2]
(iii)	P and S	
		[2]

(b) **Table 3.1** shows the properties of aluminium and silicon.

Table	9.1
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element	aluminium	silicon
melting point / °C	660	1414
electrical conductivity	very good	low

(i) State the type of structure aluminium has and explain why it is able to conduct electricity.

.....[2]

(ii) State the type of structure of silicon explain why it has a high melting point.

[2] [Total: 10]

- 4 Isoprene is a hydrocarbon with the IUPAC name 2-methylbuta-1,3-diene. It is a colourless liquid under standard conditions.
  - (a) Draw the **displayed** formula of isoprene.

(b) State and explain whether isoprene displays *cis-trans* isomerism.

(c) Penta-1,3-diene is a constitutional isomer of isoprene. **Table 4.1** shows the boiling points of penta-1,3-diene and isoprene.

compound	boiling point /°C
penta-1,3-diene	42.0
isoprene	34.1

Explain why isoprene has a lower boiling point compared to penta-1,3-diene.

 (d) The molecular formula of isoprene is  $C_5H_8$ .

Using data given in **Table 4.2**, construct an energy cycle to calculate the enthalpy change of the following reaction.

$$C_5H_8(g) + 7O_2(g) \rightarrow 5CO_2(g) + 4H_2O(l)$$
  $\Delta H_{rxn}$ 

standard enthalpy change of vaporisation of isoprene /kJ mol <sup>-1</sup>	+26.8
standard enthalpy change of formation of isoprene /kJ mol <sup>-1</sup>	+75.7
standard enthalpy change of combustion of carbon /kJ mol <sup>-1</sup>	-393
standard enthalpy change of formation of water /kJ mol <sup>-1</sup>	-286

#### Table 4.2

5 PBr<sub>3</sub> is a discrete molecule with the following structure.



(a) Predict the bond angles about the central atoms of PBr<sub>3</sub>, SiCl<sub>4</sub> and H<sub>2</sub>S.
 Hence using VSEPR theory, explain why the bond angle about the central atom of these compounds are different.

PBr <sub>3</sub> :	SiCl <sub>4</sub> :	H <sub>2</sub> S:

(b) Element **D** forms an oxide with the formula  $DO_3$ .

The electronegativity values of **D** and other elements are given in Table 5.1.

Table 5.1

Element	Electronegativity Pauling Scale
Р	2.19
Br	2.96
D	2.75
0	3.44

Using the above values, calculate the electronegativity difference between P and Br, and D and O. Hence, predict the structure and bonding present in  $DO_3$ .

 (c) PBr<sub>3</sub> reacts with BF<sub>3</sub> to form an adduct PBr<sub>3</sub>•BF<sub>3</sub>.
 Draw the structure of the adduct formed. State the type of bond formed and explain how it is formed.

[3]	
L-1	
[Total: 9]	

6 Helium is used to fill party balloons.

A 60.0 dm<sup>3</sup> industrial tank of helium gas at 25 °C and 125 atm was used to fill up some balloons. After some balloons were filled, the pressure in the tank decreased to 45 atm.

(a) Calculate the amount of helium gas present in the industrial tank initially.

(b) Determine the amount of helium gas used to fill up the balloons, assuming the temperature is constant.

(c) Assuming each balloon has a volume of 4 dm<sup>3</sup> and an internal pressure of 1.2 atm, calculate the maximum number of balloons, in whole number, that can be filled with a 60.0 dm<sup>3</sup> industrial tank of helium gas at 25 °C and 125 atm. Assume that the temperature is constant.

(d) State and briefly explain if helium gas behaves more ideally in the tank, or when present in balloons at the same temperature.

[1] [Total: 6]

**END OF SECTION B** 

[1]

[2]

[2]

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