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# Chemistry Standard level Paper 2

9 May 2024

Zone A morning | Zone B morning | Zone C morning

Candidate session number

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1 hour 15 minutes

## Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.



Answer **all** questions. Answers must be written within the answer boxes provided.

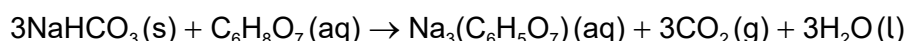
1. A powder has the following percentage composition by mass:

30.0% sucrose,  $C_{12}H_{22}O_{11}$

45.0% citric acid,  $C_6H_8O_7$

25.0% sodium hydrogencarbonate,  $NaHCO_3$

In the presence of water, the powder effervesces as the citric acid reacts with the sodium hydrogencarbonate:



(a) (i) Determine the limiting reactant when 1.00 g of this powder reacts. [3]

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(ii) Determine the volume, in  $dm^3$  at SATP, of carbon dioxide released in the reaction in (a)(i). Use sections 1 and 2 of the data booklet. [2]

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(This question continues on the following page)



**(Question 1 continued)**

- (iii) Calculate the percentage yield obtained by a student who collected  $0.043 \text{ dm}^3$  of carbon dioxide from  $1.00 \text{ g}$  of the powder.

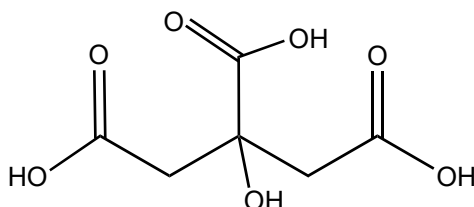
If you did not obtain an answer to (a)(ii), use  $0.068 \text{ dm}^3$ , but this is not the correct value.

[1]

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- (b) (i) State the number of acidic hydrogens in the citric acid molecule shown.

[1]



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- (ii) Deduce the structural formula of the conjugate base of citric acid.

[1]

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- (iii) Predict, giving a reason, the strength of citric acid.

[1]

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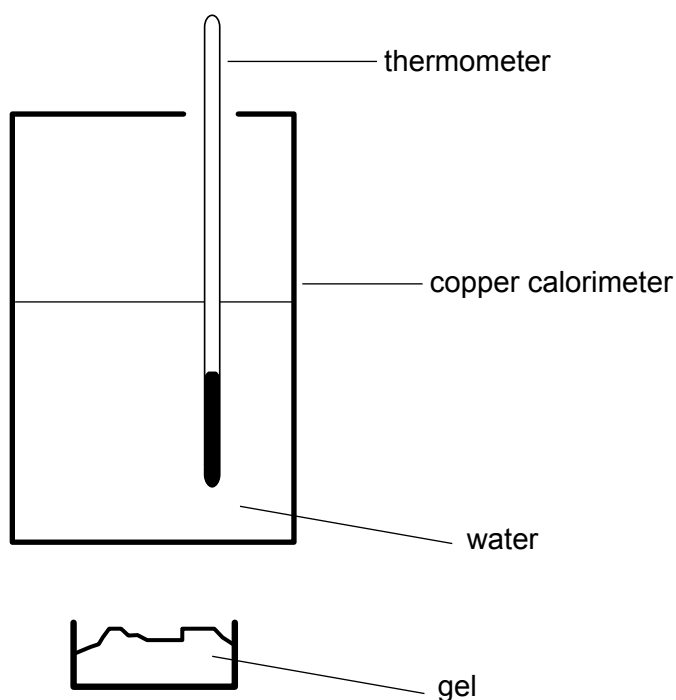
- (c) Calculate the pH of a solution with a hydrogen ion concentration,  $[\text{H}^+] = 0.0025 \text{ mol dm}^{-3}$ .

[1]

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2. A student investigated the use of hand sanitising gel containing propan-1-ol as a camping fuel.



|                                                                           |        |
|---------------------------------------------------------------------------|--------|
| Mass of water / g $\pm 0.02$ g                                            | 400.00 |
| Initial temperature of water / $^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$ | 19.0   |
| Final temperature of water / $^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$   | 40.0   |
| Initial mass of gel / g $\pm 0.01$ g                                      | 20.00  |
| Final mass of gel / g $\pm 0.01$ g                                        | 18.20  |

(a) (i) Calculate the heat energy absorbed by the water, in J. Use sections 1 and 2 of the data booklet.

[1]

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(ii) Calculate the percentage uncertainty of your answer in (a)(i).

[2]

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**(Question 2 continued)**

(iii) Suggest a way to reduce the random uncertainty of the answer. [1]

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.....

(b) (i) Calculate the enthalpy of combustion of propan-1-ol, in  $\text{kJ mol}^{-1}$ , stating **one** assumption.

If you did not obtain an answer to (a)(i), use 30 000 J, though this is not the correct value. [3]

Calculation: .....

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.....  
.....  
.....

Assumption: .....

(ii) Calculate the percentage error, using section 13 of the data booklet. [1]

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(iii) Suggest the main source of error, and a way to reduce it. [1]

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**(This question continues on the following page)**



**(Question 2 continued)**

(c) Ethanol and propan-1-ol are members of a homologous series.

(i) State the names of the class of compound and the functional group of this series. [2]

|                         |
|-------------------------|
| Class: .....            |
| Functional group: ..... |

(ii) State the strongest intermolecular force present in ethanol and propan-1-ol. [1]

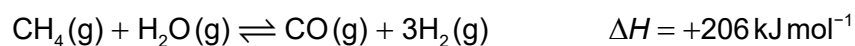
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| ..... |
|-------|

(iii) Predict an intermolecular force which would be stronger in the next member of the homologous series, butan-1-ol. [1]

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3. Hydrogen is manufactured from methane by a process called steam reforming:



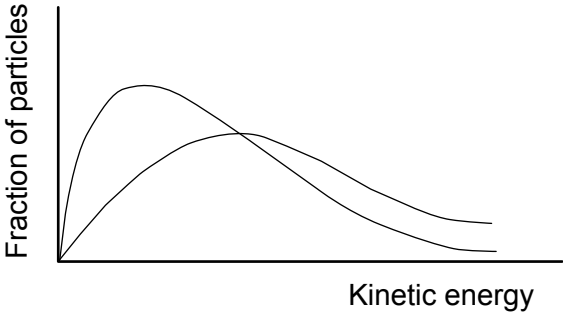
(a) Deduce the equilibrium constant,  $K_c$ , expression for the reaction. [1]

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(b) Predict, with a reason, the effect of increasing the temperature on the position of equilibrium. [1]

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(c) Explain why the reaction rate increases with temperature, adding annotations to the following Maxwell-Boltzmann graph to assist your explanation. [3]



Explanation: .....

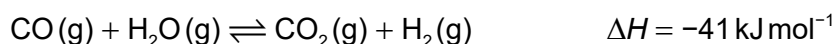
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(d) Annotate this Maxwell-Boltzmann distribution graph in (c) to show the effect of a catalyst. [1]





4. The water-gas shift reaction is another way to manufacture hydrogen.



(a) (i) State the oxidation state of carbon in carbon monoxide and carbon dioxide. [1]

|                        |
|------------------------|
| carbon monoxide: ..... |
| carbon dioxide: .....  |

(ii) Identify the oxidising and reducing agents, and the species oxidised and reduced, in the forward reaction. [2]

|                              | CO(g) | H <sub>2</sub> O(g) |
|------------------------------|-------|---------------------|
| oxidising or reducing agent? |       |                     |
| species oxidised or reduced? |       |                     |

(b) (i) Draw the Lewis structure of carbon dioxide. [1]

|       |
|-------|
| ..... |
| ..... |
| ..... |
| ..... |

(ii) Annotate the Lewis structure in (b)(i) to show the polarity of the bonds by adding the symbols δ+ and δ- as appropriate. [1]

(iii) Explain the molecular geometry and polarity of the carbon dioxide molecule. [2]

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| ..... |
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**(Question 4 continued)**

- (iv) Outline why the increase in carbon dioxide concentration in the atmosphere is of international concern. [2]

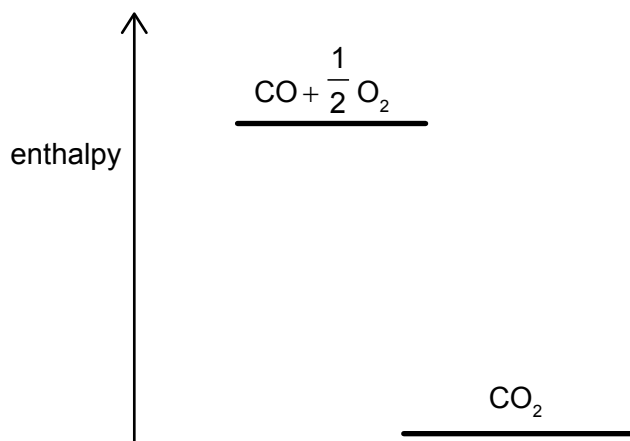
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- (v) Explain, referring to the enthalpy profile shown, whether carbon monoxide is more or less stable than carbon dioxide. [1]



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5. (a) State the electron configuration of sulfur, S. [1]

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(b) State a physical property of sulfur which supports its classification as a non-metal element. [1]

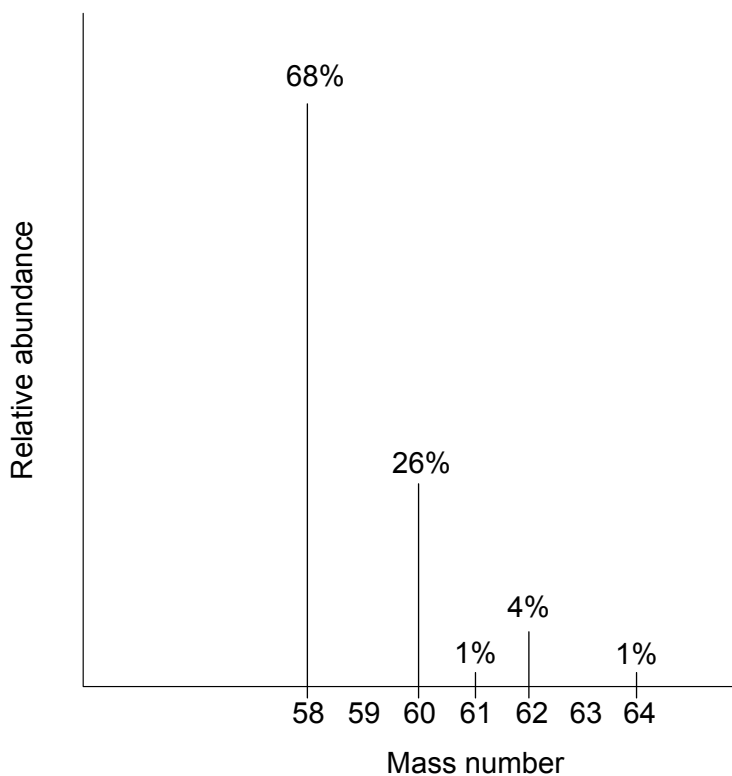
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(c) Suggest a balanced equation for the reaction of an oxide of sulfur with water. [1]

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6. (a) Determine the relative atomic mass of nickel from the mass spectrum shown. [1]



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(b) (i) Deduce the nuclear symbol,  ${}^A_ZX$ , for an ion of nickel-58 with 26 electrons. [1]

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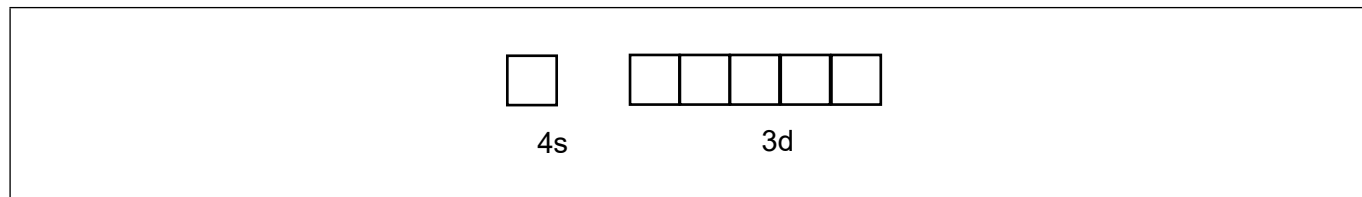
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**(Question 6 continued)**

(ii) Draw arrows to represent electrons in the orbital diagram for this ion. [1]



(iii) Explain how the ions are held together in nickel chloride, and why it only conducts electricity when molten. [2]

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7. (a) Compare the length and strength of the C–C bonds in benzene and cyclohexene, referring to sections 10 and 11 of the data booklet.

[1]

Bond length: .....

.....

Bond strength: .....

.....

- (b) Explain why the structure of benzene favours substitution and not addition reactions.

[2]

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16EP15



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16EP16