

**Chemistry**  
**Standard level**  
**Paper 2**

Wednesday 7 November 2018 (afternoon)

Candidate session number

1 hour 15 minutes

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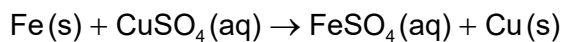
**Instructions to candidates**

- 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. 3.26 g of iron powder are added to 80.0 cm<sup>3</sup> of 0.200 mol dm<sup>-3</sup> copper(II) sulfate solution. The following reaction occurs:



- (a) (i) Determine the limiting reactant showing your working. [2]

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- (ii) The mass of copper obtained experimentally was 0.872 g. Calculate the percentage yield of copper. [2]

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- (b) (i) The reaction was carried out in a calorimeter. The maximum temperature rise of the solution was 7.5 °C.

Calculate the enthalpy change,  $\Delta H$ , of the reaction, in kJ, assuming that all the heat released was absorbed by the solution. Use sections 1 and 2 of the data booklet. [2]

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**(Question 1 continued)**

- (ii) State another assumption you made in (b)(i). [1]

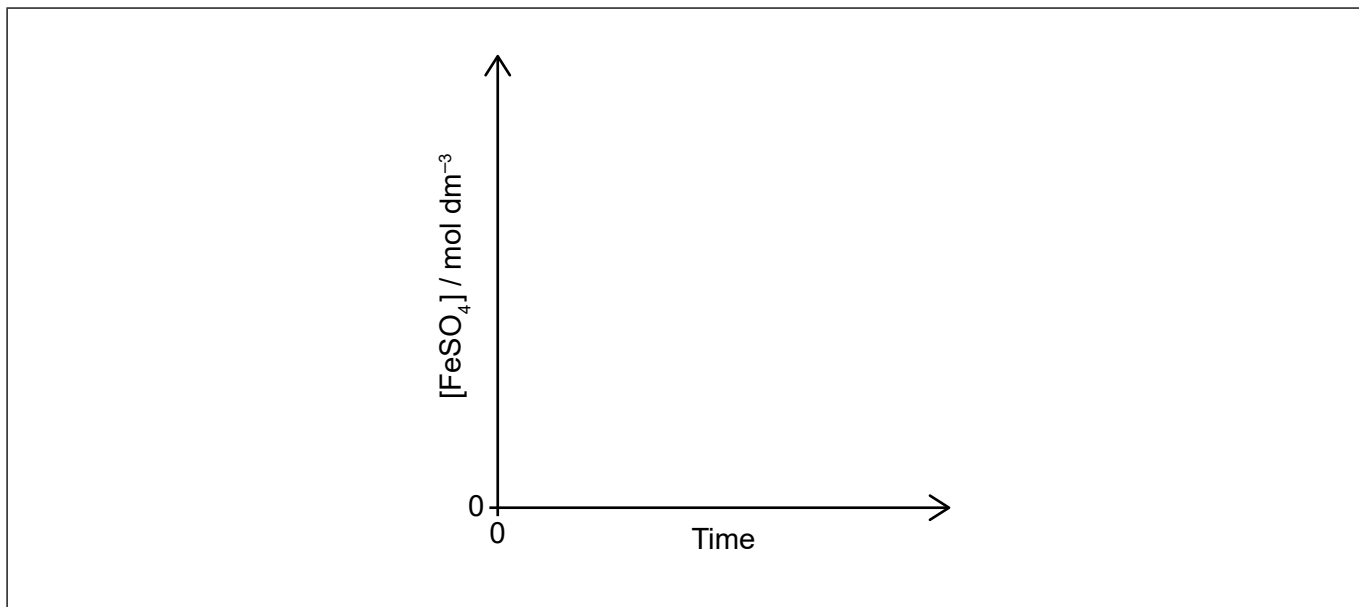
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- (iii) The only significant uncertainty is in the temperature measurement.

Determine the absolute uncertainty in the calculated value of  $\Delta H$  if the uncertainty in the temperature rise was  $\pm 0.2^\circ\text{C}$ . [2]

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- (c) (i) Sketch a graph of the concentration of iron(II) sulfate,  $\text{FeSO}_4$ , against time as the reaction proceeds. [2]



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**(Question 1 continued)**

- (ii) Outline how the initial rate of reaction can be determined from the graph in part (c)(i). [2]

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- (iii) Explain, using the collision theory, why replacing the iron powder with a piece of iron of the same mass slows down the rate of the reaction. [2]

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**2. Propan-2-ol is a useful organic solvent.**

- (a) Draw the structural formula of propan-2-ol. [1]

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- (b) Calculate the number of hydrogen atoms in 1.00 g of propan-2-ol. [2]

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**(Question 2 continued)**

(c) Classify propan-2-ol as a primary, secondary or tertiary alcohol, giving a reason. [1]

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(d) (i) State a suitable oxidizing agent for the oxidation of propan-2-ol in an acidified aqueous solution. [1]

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(ii) Deduce the average oxidation state of carbon in propan-2-ol. [1]

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(iii) Deduce the product of the oxidation of propan-2-ol with the oxidizing agent in (d)(i). [1]

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3. Bromine can form the bromate(V) ion,  $\text{BrO}_3^-$ .

(a) (i) State the electron configuration of a bromine atom. [1]

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(ii) Sketch the orbital diagram of the **valence shell** of a bromine atom (ground state) on the energy axis provided. Use boxes to represent orbitals and arrows to represent electrons. [1]

Energy



(b) Draw the Lewis (electron dot) structure for  $\text{BrO}_3^-$  that obeys the octet rule. [1]

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**(Question 3 continued)**

- (c) Predict, using the VSEPR theory, the geometry of the  $\text{BrO}_3^-$  ion and the O–Br–O bond angles. [3]

Geometry:  
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Reason:  
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O–Br–O angle:  
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- (d) (i) Bromate(V) ions act as oxidizing agents in acidic conditions to form bromide ions.

Deduce the half-equation for this reduction reaction. [2]

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- (ii) Bromate(V) ions oxidize iron(II) ions,  $\text{Fe}^{2+}$ , to iron(III) ions,  $\text{Fe}^{3+}$ .

Deduce the equation for this redox reaction. [1]

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4. Properties of elements and their compounds can be related to the position of the elements in the periodic table.

(a) Explain the decrease in atomic radius from Na to Cl. [2]

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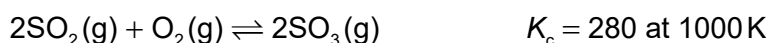
(b) (i) Explain why the radius of the sodium ion, Na<sup>+</sup>, is smaller than the radius of the oxide ion, O<sup>2-</sup>. [2]

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(ii) State a physical property of sodium oxide. [1]

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5. This reaction is used in the manufacture of sulfuric acid.



(a) State why this equilibrium reaction is considered homogeneous. [1]

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**(Question 5 continued)**

- (b) 0.200 mol sulfur dioxide, 0.300 mol oxygen and 0.500 mol sulfur trioxide were mixed in a 1.00 dm<sup>3</sup> flask at 1000 K.

Predict the direction of the reaction showing your working.

[3]

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6. Butanoic acid, CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>COOH, is a weak acid and ethylamine, CH<sub>3</sub>CH<sub>2</sub>NH<sub>2</sub>, is a weak base.

(a) State the equation for the reaction of each substance with water.

[2]

Butanoic acid:  
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Ethylamine:  
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(b) Explain why butanoic acid is a liquid at room temperature while ethylamine is a gas at room temperature.

[2]

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12EP09

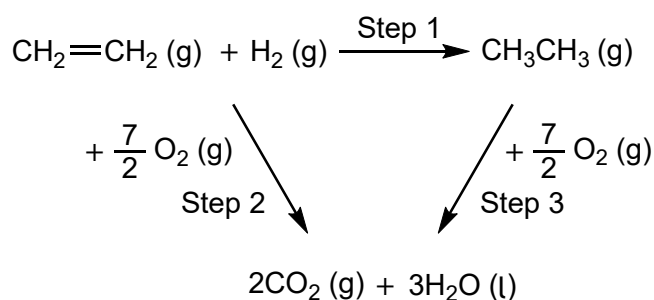
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(Question 6 continued)

- (c) State the formula of the salt formed when butanoic acid reacts with ethylamine. [1]

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7. Consider the following Hess's law cycle:



- (a) Identify the type of reaction in step 1. [1]

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- (b) Calculate the standard enthalpy change,  $\Delta H^\ominus$ , of step 2 using section 13 of the data booklet. [1]

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- (c) Determine the standard enthalpy change,  $\Delta H^\ominus$ , of step 1. [1]

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**(Question 7 continued)**

- (d) Suggest one reason why the calculated value of  $\Delta H^\ominus$  using Hess's Law in part (c) can be considered accurate and one reason why it can be considered approximate. [2]

Accurate:

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Approximate:

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12EP11

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Answers written on this page  
will not be marked.



12EP12