Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 2

Wednesday 7 November 2018 (afternoon)

Candidate session number

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]**.

8818 – 6105

11 pages

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^3 of 0.200 mol dm^{-3} copper(II) sulfate solution. The following reaction occurs:

$$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$$

(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, ΔH, 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 ΔH if the uncertainty in the temperature rise was $\pm 0.2\,^{\circ}C$. [2]

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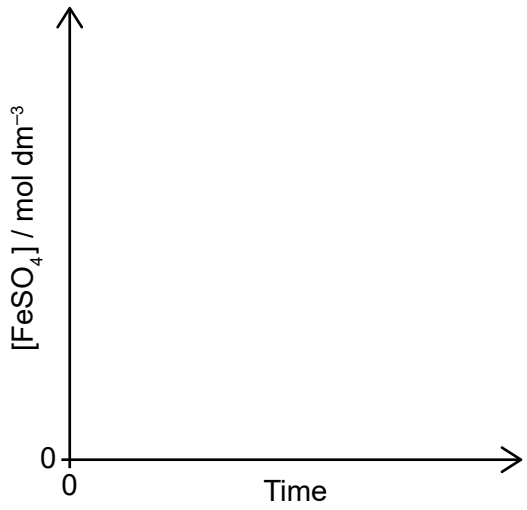
(c) (i) Sketch a graph of the concentration of iron(II) sulfate, $FeSO_4$, against time as the reaction proceeds. [2]



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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]

(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, 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]

(b) Draw the Lewis (electron dot) structure for BrO_3^- that obeys the octet rule. [1]

(This question continues on the following page)

(Question 3 continued)

(c) Predict, using the VSEPR theory, the geometry of the BrO_3^- ion and the O–Br–O bond angles. [3]

Geometry:

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Reason:

. . . . . .

. . . . . .

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, Fe^{2+}, to iron(III) ions, 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^+, is smaller than the radius of the oxide ion, O^{2-}. [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.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad K_c = 280 \text{ at } 1000\,K$$

(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^3 flask at 1000 K.

Predict the direction of the reaction showing your working. [3]

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6. Butanoic acid, $CH_3CH_2CH_2COOH$, is a weak acid and ethylamine, $CH_3CH_2NH_2$, 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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(Question 6 continued)

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

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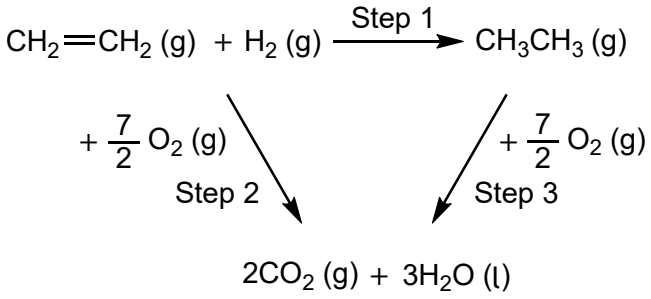
7. Consider the following Hess's law cycle:



(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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Please **do not** write on this page.

Answers written on this page
will not be marked.