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Chemistry
Standard level
Paper 2

Thursday 5 November 2020 (afternoon)

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. Chlorine undergoes many reactions.

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

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(ii) State, giving a reason, whether the chlorine atom or the chloride ion has a larger radius. [1]

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(iii) Outline why the chlorine atom has a smaller atomic radius than the sulfur atom. [2]

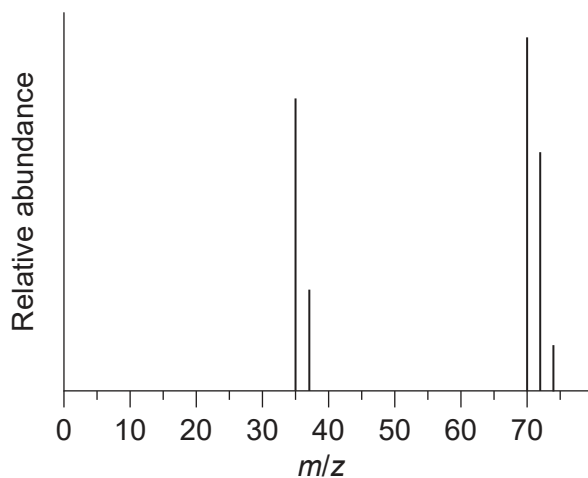
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(This question continues on the following page)



(Question 1 continued)

(iv) The mass spectrum of chlorine is shown.



Outline the reason for the two peaks at $m/z = 35$ and 37 .

[1]

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(v) Explain the presence and relative abundance of the peak at $m/z = 74$.

[2]

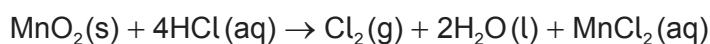
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(b) 2.67 g of manganese(IV) oxide was added to 200.0 cm³ of 2.00 mol dm⁻³ HCl.



(i) Calculate the amount, in mol, of manganese(IV) oxide added.

[1]

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(This question continues on the following page)



12EP03

Turn over

(Question 1 continued)

(ii) Determine the limiting reactant, showing your calculations. [2]

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(iii) Determine the excess amount, in mol, of the other reactant. [1]

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(iv) Calculate the volume of chlorine, in dm³, produced if the reaction is conducted at standard temperature and pressure (STP). Use section 2 of the data booklet. [1]

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(v) State the oxidation state of manganese in MnO₂ and MnCl₂. [2]

MnO₂:
.....

MnCl₂:
.....

(vi) Deduce, referring to oxidation states, whether MnO₂ is an oxidizing or reducing agent. [1]

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(This question continues on the following page)



12EP04

(Question 1 continued)

(c) Chlorine gas reacts with water to produce hypochlorous acid and hydrochloric acid.



(i) Hypochlorous acid is considered a weak acid. Outline what is meant by the term weak acid. [1]

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(ii) State the formula of the conjugate base of hypochlorous acid. [1]

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(iii) Calculate the concentration of $\text{H}^+(\text{aq})$ in a $\text{HClO}(\text{aq})$ solution with a $\text{pH} = 3.61$. [1]

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(d) (i) State the type of reaction occurring when ethane reacts with chlorine to produce chloroethane. [1]

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(ii) Predict, giving a reason, whether ethane or chloroethane is more reactive. [1]

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(This question continues on the following page)



(Question 1 continued)

- (iii) Write the equation for the reaction of chloroethane with a dilute aqueous solution of sodium hydroxide. [1]

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- (iv) Deduce the nucleophile for the reaction in d(iii). [1]

.....

- (v) Ethoxyethane (diethyl ether) can be used as a solvent for this conversion. Draw the structural formula of ethoxyethane. [1]

- (vi) Deduce the number of signals and their chemical shifts in the ^1H NMR spectrum of ethoxyethane. Use section 27 of the data booklet. [2]

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(Question 1 continued)

(e) CCl_2F_2 is a common chlorofluorocarbon, CFC.

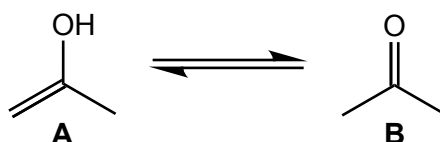
(i) Calculate the percentage by mass of chlorine in CCl_2F_2 . [2]

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(ii) Comment on how international cooperation has contributed to the lowering of CFC emissions responsible for ozone depletion. [1]

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2. Compound **A** is in equilibrium with compound **B**.



(a) Predict the electron domain and molecular geometries around the **oxygen** atom of molecule **A** using VSEPR. [2]

Electron domain geometry:
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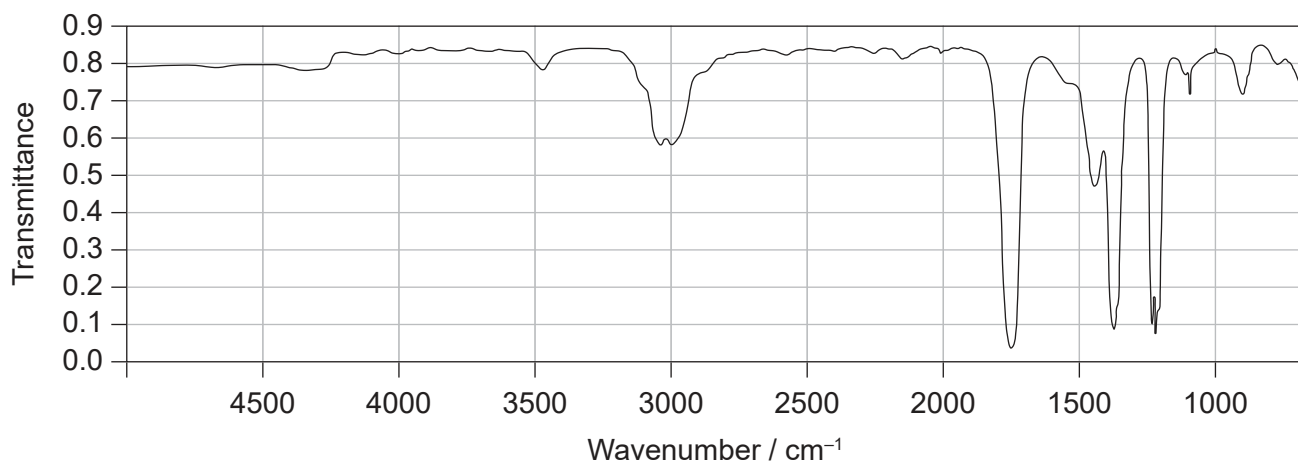
Molecular geometry:
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(Question 2 continued)

(b) The IR spectrum of one of the compounds is shown:



Deduce, giving a reason, the compound producing this spectrum.

[1]

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(c) Compound **A** and **B** are isomers. Draw two other structural isomers with the formula C_3H_6O .

[2]

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12EP08

(Question 2 continued)

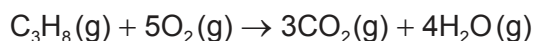
(d) The equilibrium constant, K_c , for the conversion of **A** to **B** is 1.0×10^8 in water at 298 K.

Deduce, giving a reason, which compound, **A** or **B**, is present in greater concentration when equilibrium is reached.

[1]

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3. An equation for the combustion of propane is given below.



(a) Determine the standard enthalpy change, ΔH^\ominus , for this reaction, using section 11 of the data booklet.

[3]

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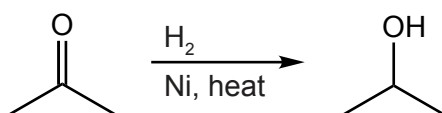
(b) Calculate the standard enthalpy change, ΔH^\ominus , for this reaction using section 12 of the data booklet.

[2]

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4. Nickel catalyses the conversion of propanone to propan-2-ol.



(a) Outline how a catalyst increases the rate of reaction. [1]

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(b) Explain why an increase in temperature increases the rate of reaction. [2]

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(c) Discuss, referring to intermolecular forces present, the relative volatility of propanone and propan-2-ol. [3]

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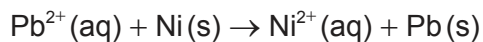
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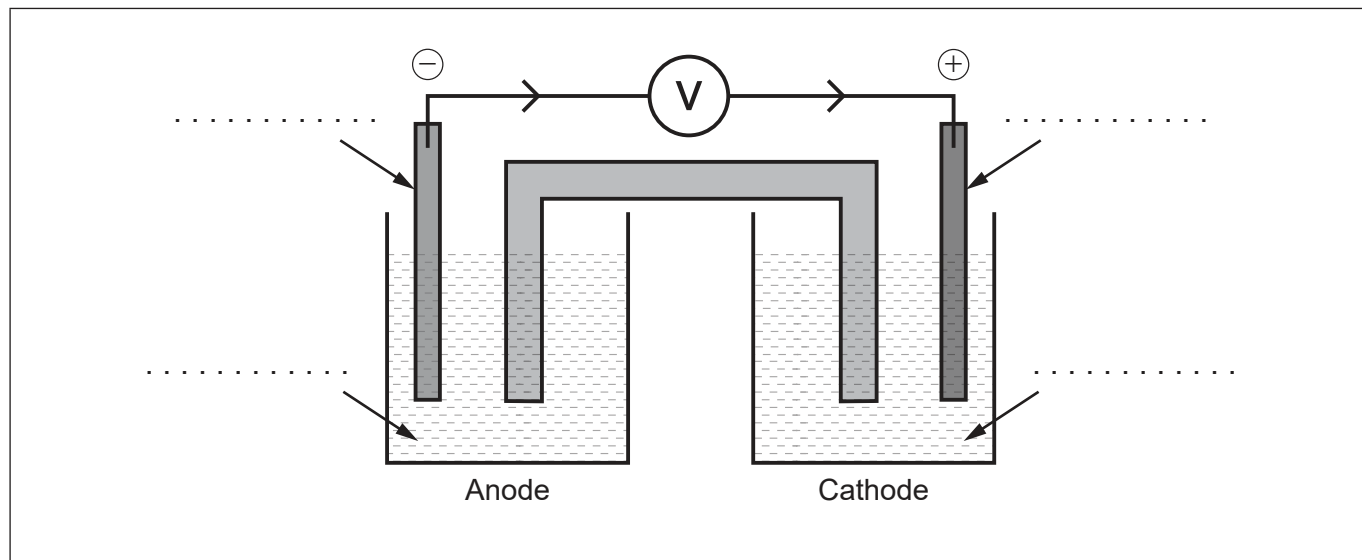
(Question 4 continued)

(d) (i) The diagram shows an unlabelled voltaic cell for the reaction



Label the diagram with the species in the equation.

[1]



(ii) Suggest a metal that could replace nickel in a new half-cell and reverse the electron flow. Use section 25 of the data booklet.

[1]

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(iii) Describe the bonding in metals.

[2]

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(iv) Nickel alloys are used in aircraft gas turbines. Suggest a physical property altered by the addition of another metal to nickel.

[1]

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References:

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- 2.(b) COBLENTZ SOCIETY. Collection © 2018 copyright by the U.S. Secretary of Commerce on behalf of the United States of America. All rights reserved.



12EP12