GCE A LEVEL CHEMISTRY

S21-A410

Assessment Resource G

Physical and Inorganic Chemistry

1. Give the formulae of the **four** sulfur-containing products of the reaction of sodium iodide, NaI, with concentrated sulfuric acid. [2]

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2. The boiling temperatures of three compounds are shown below.

Compound	ammonia, NH_3	phosphine, PH_3	arsine, AsH_3
Boiling temperature / °C	–33	–88	–63

(a) Explain why the boiling temperature of ammonia is much higher than that of phosphine and arsine. [2]

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(b) Give a reason why the boiling temperature of arsine is higher than that of phosphine. [1]

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3. Carboxylic acids are weak acids. The table below gives the K_a values for some carboxylic acids.

Acid	K_a / mol dm^{-3}
ethanoic acid, CH_3COOH	1.74×10^{-5}
chloroethanoic acid, $ClCH_2COOH$	1.43×10^{-3}
dichloroethanoic acid, $Cl_2CHCOOH$	5.13×10^{-2}
trichloroethanoic acid, Cl_3CCOOH	2.24×10^{-1}

(a) Describe how the replacement of hydrogen atoms by chlorine atoms affects the strength of the acid. [1]

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(b) Find the pH of a solution of chloroethanoic acid of concentration 0.200 mol dm^{-3}. [2]

pH = ...

(c) The soluble salt sodium ethanoate can be produced from ethanoic acid. A student suggests the following method:

- Measure 25 cm^3 of a solution of ethanoic acid of concentration 0.200 mol dm^{-3} in a measuring cylinder.
- Transfer to a conical flask and add a few drops of methyl orange indicator. This is selected because it changes colour in a pH range of 3.1-4.4.
- Add sodium hydroxide solution of concentration 2.00 mol dm^{-3} from a burette until the indicator changes colour.
- Record the volume of sodium hydroxide required.
- Measure another 25 cm^3 of the ethanoic acid solution.
- Add the same volume of sodium hydroxide as in the first experiment, this time without an indicator.
- Transfer the solution to an evaporating basin and evaporate most of the water.
- Leave the hot solution to cool and allow crystals to form. Filter these away from the solution.

(i) The teacher tells the student that their proposed method would form 0.68 g of sodium ethanoate trihydrate ($CH_3COONa.3H_2O$) and that the solubility of this compound is 2.42 mol dm^{-3} at 20 °C.

Find the minimum volume of water needed to dissolve the mass of sodium ethanoate trihydrate formed at 20 °C and hence suggest why the final step in the method may not be successful. [3]

Miniumum volume = ... cm^3

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(ii) Suggest **three** changes that should be made to this method, giving reasons for each. [5]

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4. Fuel cells are an electrochemical method of obtaining energy from fuels.

(a) Give **one** advantage and **one** disadvantage of the use of fuel cells. [2]

Advantage .....

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Disadvantage .....

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(b) Hydrogen gas is a common fuel used in fuel cells. Hydrogen can be produced in the electrolysis of sodium chloride solution. The reaction occurring is shown below.

$$2NaCl(aq) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g) + Cl_2(g)$$

(i) Electrolysis was undertaken on 250 cm^3 of a solution of sodium chloride of concentration 5.00 mol dm^{-3} until 2856 cm^3 of hydrogen gas was produced at a temperature of 320 K and a pressure of 1.14×10^5 Pa.

Calculate the concentration of the sodium hydroxide present at the end of the process. [4]

Concentration = ... mol dm^{-3}

(ii) The chlorine gas produced in the reaction was stored under a pressure of 5.05×10^5 Pa at a temperature of 283 K.

Calculate the volume of the chlorine gas under these conditions. [2]

Volume = ... cm^3

(iii) At the end of the electrolysis process the solution contained a base and a salt. A student suggests that this could therefore be used as a buffer. Is the student correct? Explain your answer. [3]

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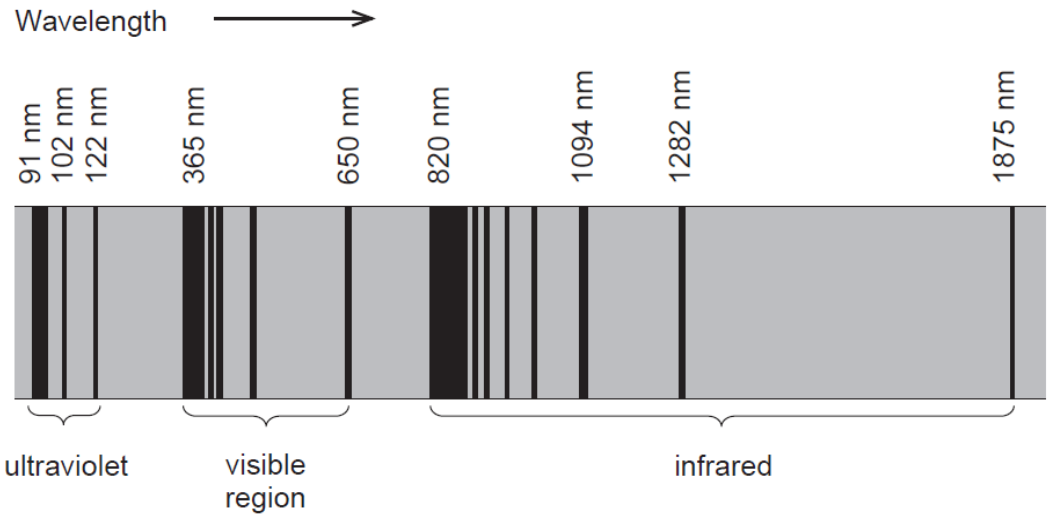
(c) When an electrical discharge is passed through hydrogen gas, the atoms emit light and other frequencies of electromagnetic radiation. These form the emission spectrum shown below.



Explain why this pattern of sharp lines forms and how it can be used to find the ionisation energy of hydrogen. You should also calculate the ionisation energy of hydrogen in $kJ\,mol^{-1}$. [6 QER]

Ionisation energy = ... $kJ\,mol^{-1}$

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(d) Another fuel that can be used in fuel cells is methanol. The equation for the combustion of gaseous methanol at a temperature of 120°C is given below.

$$2CH_3OH(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(g) \qquad \Delta H = -1286\,kJ\,mol^{-1}$$

(i) Calculate the bond energy of the C—O bond in methanol. [3]

Bond	Bond energy / kJ mol^{-1}
C—H	414
O=O	498
O—H	464
C=O	803

Bond energy = ... kJ mol^{-1}

(ii) Give a reason why the value calculated in part (i) may not precisely match the actual energy of this C—O bond. [1]

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(iii) The standard enthalpy change of combustion of methanol has a value of $-715\,kJ\,mol^{-1}$. Give reasons why this value is very different from the value associated with the equation. [3]

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