GCE A LEVEL CHEMISTRY

S21-A410

Assessment Resource B

Physical and Inorganic Chemistry

1. *(a)* Give the electronic structure of an atom of phosphorus. [1]

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(b) Explain why the first ionisation energy of phosphorus is greater than that of sulfur. [2]

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2. Chlorine and sodium hydroxide can react together in a disproportionation reaction.

(a) Balance the equation. [1]

..... Cl_2 + ... NaOH ⟶ ..... NaCl + ... $NaClO_3$ + ... H_2O

(b) Use oxidation states to explain why this is a disproportionation reaction. [2]

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3. Industrial processes are designed to give the maximum yield of the pure product in the shortest time at the lowest possible cost. The choice of temperature, pressure and catalyst are all key factors of designing an industrial process.

(a) (i) The Wacker process is used to produce ethanal from ethene. It is a reaction catalysed by a mixed catalyst containing chlorides of copper and palladium. The reaction may be carried out in the gas phase according to the equation below.

$$C_2H_4(g) + \tfrac{1}{2}O_2(g) \rightleftharpoons CH_3CHO(g) \qquad \Delta H^{\theta} = -218\ kJ\,mol^{-1}$$

Outline the factors that would need to be considered when selecting conditions for this process, applying these to suggest appropriate conditions. You should include a full explanation of why catalysts are very important for exothermic equilibria such as this. [6 QER]

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(ii) This industrial process has a yield of 95.0%. Calculate the mass of ethanal, in kg, that would be produced from 2.00 tonnes of ethene. [3]

Mass of ethanal = ... kg

(b) This process uses a catalyst mixture that contains $CuCl_2$.

When copper(II) compounds are dissolved in water they appear pale blue, whilst copper(I) compounds are not coloured.

(i) Give the formula of the complex ion present in dilute aqueous solutions of copper(II) compounds. [1]

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(ii) Explain why copper(I) compounds are not coloured. [2]

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(iii) State the colour change that occurs when concentrated ammonia solution is added to copper(II) compounds in aqueous solution, drawing the structure of the copper-containing ion present. Explain why the addition of ammonia solution causes the colour to change. [4]

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4. Ethyne, H—C≡C—H, is commonly known as acetylene and is burned as a fuel in oxy-acetylene welding torches. It is stored in cylinders where the gas is dissolved in propanone and this is adsorbed onto an inert substance and kept under pressure.

(a) Propanone is used to dissolve the ethyne as this gas is only slightly soluble in water. State why the solubility of ethyne in water is low. [1]

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(b) (i) When used in an oxy-acetylene torch the ethyne is released at a pressure of 135 kPa at 20 °C. Find the number of moles of ethyne in 1 cm^3 and hence calculate the density of ethyne gas, in g cm^{-3}, at this pressure at 20 °C. [4]

density = mass ÷ volume

Density = ... g cm^{-3}

(ii) The density of dry air at 0 °C and 135 kPa is 1.27×10^{-3} g cm^{-3}. A student says that this shows that a vessel of negligible mass filled with ethyne will float in air. Calculate the density of dry air at 20 °C and 135 kPa and show whether the student is correct.

[2]

Density = ... g cm^{-3}

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(c) A student wrote the equation below for the standard enthalpy of combustion ($\Delta_c H^\theta$) of ethyne.

$$2C_2H_2(g) + 5O_2(g) \longrightarrow 4CO_2(g) + 2H_2O(g)$$

(i) Identify **two** errors that the student has made. [2]

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(ii) The student found the following data in a reference source. He wanted to calculate the most accurate value for the enthalpy change for his reaction.

	Standard enthalpy values / kJ mol^{-1}
$\Delta_f H^\ominus$ [$C_2H_2(g)$]	227
$\Delta_f H^\ominus$ [$CO_2(g)$]	–394
$\Delta_f H^\ominus$ [$H_2O(l)$]	–242
$\Delta_{vaporisation} H^\ominus$ [$H_2O(l)$]	41

Bond	Bond energy / kJ mol^{-1}
C—H	412
C≡C	837
C=O	743
O—H	463
O=O	496

Select appropriate data to calculate the **most accurate** value you can for the enthalpy change for the reaction below. Explain your choice of method. [4]

$$2C_2H_2(g) + 5O_2(g) \longrightarrow 4CO_2(g) + 2H_2O(g)$$

Enthalpy change of reaction = ... kJ mol^{-1}

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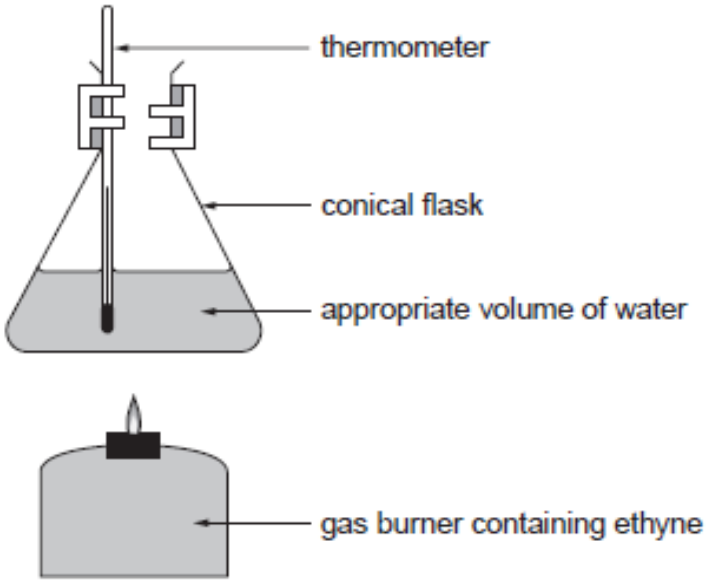
(iii) The student decided to compare his value with one obtained experimentally. He used the apparatus and method given below.



Method

Measure an appropriate volume of water into the conical flask.

Measure the mass of the gas burner containing the ethyne on a 3 decimal place balance.

Select a thermometer that has 0.2 °C as its smallest division and place this in the conical flask.

Record the temperature of the water and then immediately light the gas burner.

Heat the water for 2 minutes.

Extinguish the gas burner and record the temperature of the water and the mass of the gas burner.

I. The difference between the initial and final temperature readings is 37.4 °C. Calculate the percentage error in this value. [1]

Percentage error = ... %

II. An appropriate volume of water was selected for the experiment. Explain why a volume which was **much** smaller or **much** greater than this would give results which were of a lower accuracy. [2]

Much smaller volume of water .....

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Much greater volume of water .....

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III. Suggest **two** improvements to the method and explain how these would lead to improved results. [2]

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