UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

9145905666

CHEMISTRY **9701/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2013**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **9** printed pages and **3** blank pages.

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1 Air, which is 99% nitrogen and oxygen, is slightly soluble in water. At 25 °C a saturated solution of air in water has a concentration of $19\,cm^3\,dm^{-3}$. When water is boiled all the dissolved air is boiled out of solution.

(a) **(i)** The molar enthalpies of solution for nitrogen and oxygen are:

$$\Delta H_{soln}\ N_2 = -1.04\,kJ\,mol^{-1} \quad \text{and} \quad \Delta H_{soln}\ O_2 = -1.20\,kJ\,mol^{-1}$$

Predict how the solubility of air in water will change as the temperature is increased. Explain this prediction using Le Chatelier's principle in terms of the equilibrium between air and the aqueous solution as the temperature is increased.

Prediction ....

....

Explanation ....

....

....

....

(ii) Display your prediction in the form of a sketch graph for the solubility of air between 0 °C and 100 °C, labelling clearly the axes. Include labelled points to indicate the solubility of air at 25 °C and 100 °C.

[4]

(b) If you were to carry out an experiment to investigate how the **solubility** of air varies as the **temperature increases** name,

(i) the independent variable, ...

(ii) the dependent variable. ....

[1]

[Total: 5]

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2 When heated, aqueous hydrogen peroxide, H_2O_2, decomposes to form oxygen and water.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The decomposition can also occur at room temperature if a suitable catalyst is added. Both of the solids, manganese(IV) oxide and lead(IV) oxide, will catalyse the decomposition.

The following information gives some of the hazards associated with manganese(IV) oxide and lead(IV) oxide.

Manganese(IV) oxide: Poisoning can occur by inhalation or swallowing the powder.
Lead(IV) oxide: Poisoning can occur by inhalation or swallowing the powder. The powder can also cause skin irritation.

You are provided with a 0.300 mol dm^{-3} solution of hydrogen peroxide and a syringe with a capacity of 100 cm^3.

(a) Provide the following information about experiments you would carry out to collect oxygen from the decomposition of hydrogen peroxide and to determine, using identical masses, which of the two catalysts was the most efficient at promoting this decomposition:

- a fully labelled diagram of the apparatus to be used that would ensure that no oxygen would be lost when the experiment was carried out,
- a calculation of the maximum volume in cm^3 of the aqueous hydrogen peroxide that could be used such that the oxygen produced would not exceed the volume of the syringe,
- a statement of the measurements you would take that would allow you to say which of the catalysts was most efficient.

The molar volume of a gas at 25 °C is 24.0 dm^3.

Please continue into the space provided on the next page if necessary.

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[6]

(b) What other feature of the catalyst should be controlled?

....

....

.... [1]

(c) If one of the experiments takes 2 minutes to complete, draw a sketch graph with labelled axes showing how the volume of oxygen produced will vary with time between 0 and 3 minutes.

[2]

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(d) State the hazards that might be encountered when using the solids required in this experiment and give the **one** essential precaution you would take to make sure these chemicals were handled safely during the experiments.

....

....

.... [1]

[Total: 10]

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3 In the fractional distillation of two liquids which are miscible (dissolve in each other) in all proportions the more volatile of the two will distil first. At any temperature the composition of the vapour in equilibrium with the liquid has a higher proportion of the more volatile component which has a lower boiling point.

An experiment was carried out to investigate the boiling points of mixtures of tetrachloromethane, CCl_4,and tetrachloroethane, $C_2H_2Cl_4$.

A convenient method for representing the composition of the mixtures, both liquid and vapour, is to use the concept of **mole fraction**. For example, if the liquid mixture consists of 0.15 mole of liquid **A** and 0.35 mole of liquid **B**, the mole fraction of **A** is $\frac{0.15}{(0.15 + 0.35)}$ i.e. 0.30.

(a) The results of several of these experiments are recorded below.

temperature / °C	120.0	108.5	99.3	93.0	89.3	83.3	79.9	76.0
mole fraction CCl_4 liquid	0.000	0.100	0.200	0.300	0.400	0.600	0.800	1.000
mole fraction CCl_4 vapour	0.000	0.469	0.552	0.800	0.861	0.918	0.958	1.000

Calculate the relative molecular masses (M_rs) of CCl_4 and $C_2H_2Cl_4$.

[A_r: H, 1.0; C, 12.0; C*l*, 35.5] [1]

(b) **(i)** The vapour from the equilibrium at 108.5 °C was analysed and found to consist of 7.22 g of CCl_4 and 8.92 g of $C_2H_2Cl_4$. Show clearly by calculation that this gives a mole fraction of 0.469 for CCl_4 vapour.

(ii) The vapour from the equilibrium at 83.3 °C was analysed and found to consist of 14.14 g of CCl_4 and 1.38 g of $C_2H_2Cl_4$. Show clearly by calculation that this gives a mole fraction of 0.918 for CCl_4 vapour.

[2]

(c) On the same axes, plot two graphs, one for the liquid and one for the vapour, to show the variation in temperature (y-axis) with the mole fraction compositions (x-axis) of both the liquid and the vapour.
Draw **two lines** of best fit. Each line could be either a **curved line or a straight line**.

[4]

(d) Circle and label on the graph the point you consider to be the most anomalous.
Do not circle or label any other point.
If it is assumed that the analysis was carried out accurately, suggest a reason why the point might be anomalous.

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.... [2]

(e) By drawing an appropriate construction line on your graphs, determine the mole fraction of CCl_4 in the vapour which is in equilibrium with a liquid with a mole fraction of 0.500 CCl_4.

[2]

(f) The temperatures were measured using a thermometer calibrated in 0.1 °C graduations. If the thermometer had only been calibrated in 1.0 °C graduations, calculate the percentage errors which would result from the determination of the boiling points of each of the two pure liquids.

[2]

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(g) (i) Use your graphs to state whether CCl_4 or $C_2H_2Cl_4$ distills first from a mixture of the two liquids.

....

(ii) Explain your answer **(i)**.

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.... [2]

[Total: 15]

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