Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number

Candidate Number

Chemistry

Advanced Subsidiary

Unit 3: Chemistry Laboratory Skills I

Thursday 21 January 2016 – Morning
Time: 1 hour 15 minutes

Paper Reference
WCH03/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

6/6/6/6/

P 4 6 9 3 9 A 0 1 2 0

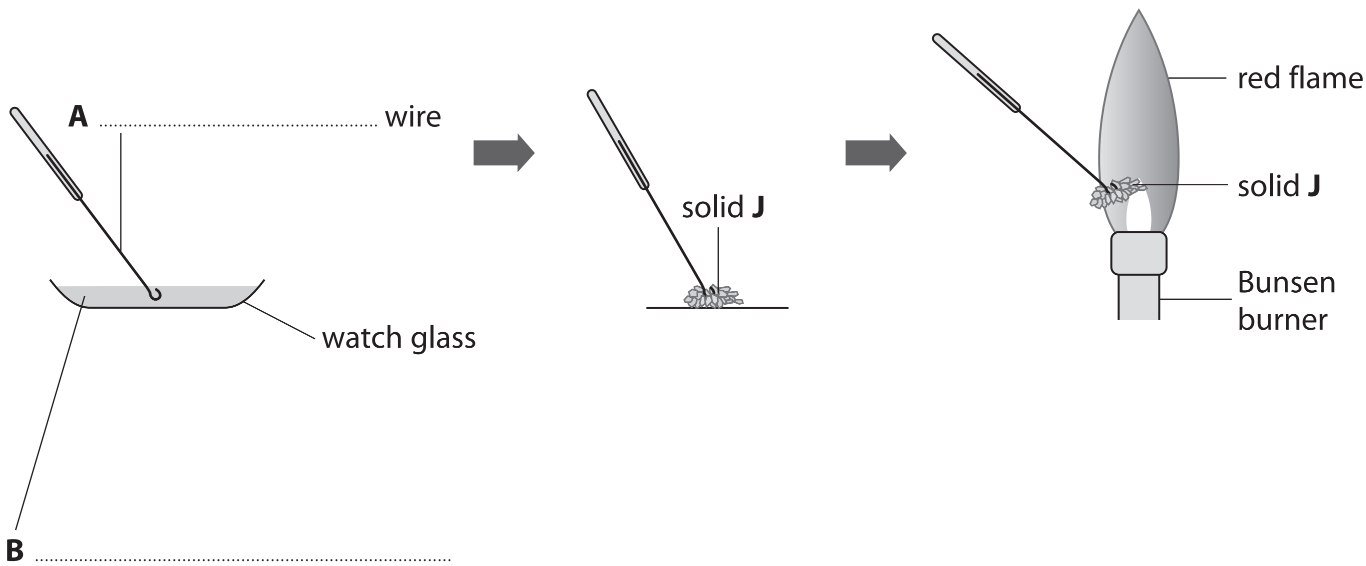
PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 A series of tests is carried out on a white solid, **J**, which is a mixture of two compounds. One compound contains a Group 1 cation, and the other a Group 2 cation. The two compounds contain the same anion.

(a) Complete the labels **A** and **B** in the diagram below, which shows the procedure and result for a flame test on solid **J**.

(2)



(b) It is known that the Group 2 cation in **J** gives no colour in a flame test, so the red colour seen must be due to the Group 1 cation.

Give the name or formula of the Group 1 cation, which is responsible for the red colour observed in the flame test, and give the name or formula of the Group 2 cation.

(2)

Group 1 cation ....

Group 2 cation ....

(c) Dilute hydrochloric acid is added to a sample of **J**.
J dissolves in the acid but there is no other change.

(i) If **J** contained a carbonate anion, what would be the observation on the addition of dilute hydrochloric acid?

(1)

....

(ii) Give the name or formula of another anion which would produce the same observation with dilute hydrochloric acid as the carbonate anion.

(1)

....

(iii) Aqueous barium chloride is then added to the solution of **J** in hydrochloric acid. A white precipitate forms.

Give the **formulae** for the two salts present in **J**.

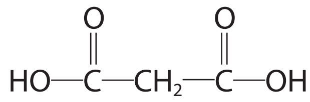
(2)

....

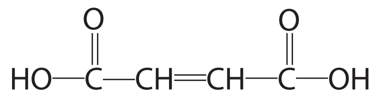
....

(Total for Question 1 = 8 marks)

2 This question is about the following two dicarboxylic acids.
Both acids are solid at room temperature.



Propanedioic acid



Butenedioic acid

(a) (i) Phosphorus(V) chloride is often used to confirm the presence of an —OH group in a compound.

Suggest a practical problem if solid phosphorus(V) chloride is used with these two dicarboxylic acids.

(1)

....

....

....

(ii) Suggest a reagent that could be used to confirm the presence of an **acid** group in either of the two compounds above, and the positive observation that would be made.

(2)

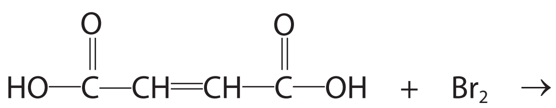
Reagent ....

Observation ....

(b) Bromine dissolved in an organic solvent reacts rapidly with butenedioic acid.

Complete the equation for the reaction of butenedioic acid with bromine.

(1)



(c) Propanedioic acid can be produced by the oxidation of propane-1,3-diol.

(i) Draw the **skeletal** formula of propane-1,3-diol.

(1)

(ii) Identify **one** way in which the infrared spectrum of propanedioic acid would be different from that of the infrared spectrum of propane-1,3-diol.

Wavenumber data are not required.

(1)

....

....

....

(Total for Question 2 = 6 marks)

3 Washing soda is hydrated sodium carbonate, $Na_2CO_3.xH_2O$, where the number of moles of water of crystallization, x, can vary.

A sample of washing soda is analysed. Two methods are used to determine the value of x in the sample.

Method 1: Heating

2.50 g of the washing soda is placed in a crucible. The crucible is gently heated for three minutes and then heated strongly for five minutes. The mass of the solid after heating is 1.06 g.

$$Na_2CO_3.xH_2O(s) \rightarrow Na_2CO_3(s) + xH_2O(g)$$ **Equation 1**

(a) Suggest why the crucible is heated gently for the first three minutes.

(1)

....

....

(b) What additional step after heating strongly for five minutes is needed to make sure that all of the water of crystallization has been removed?

(1)

....

....

(c) What is the correct chemical term for sodium carbonate without water of crystallization?

(1)

....

(d) (i) Calculate the number of moles of sodium carbonate that remain after heating the sample, assuming that all of the water of crystallization has been removed.

(2)

(ii) Calculate the number of moles of water lost from the sample of washing soda on heating.

(1)

(iii) Hence deduce the value of x in the sample of washing soda, $Na_2CO_3.xH_2O$, obtained using Method 1.

(1)

x = ...

Method 2: Titration

Sodium carbonate reacts with hydrochloric acid as follows:

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O \qquad \textbf{Equation 2}$$

A 2.50 g sample of the washing soda is placed in a beaker and dissolved in deionized water. This solution is poured into a 250 cm^3 volumetric flask, made up to the mark and mixed thoroughly.

A pipette is then used to transfer 25.00 cm^3 of the washing soda solution to each of three conical flasks. A burette is filled with hydrochloric acid, of concentration 0.100 mol dm^{-3}, and titrations are carried out. The results are shown in the table.

Titration numbers	1	2	3
Burette reading (final) / cm^3	17.00	33.55	16.45
Burette reading (initial) / cm^3	0.00	17.00	0.00
Titre / cm^3	17.00	16.55	16.45

(e) What should be done to make sure that all of the washing soda is transferred to the volumetric flask?

(1)

....

....

(f) Explain why only titrations 2 and 3 are used to calculate the mean titre.

(1)

....

....

(g) (i) Calculate the mean titre, and then calculate the number of moles of hydrochloric acid in the mean titre.

(1)

(ii) Using your answer to part (g)(i) and **Equation 2**, calculate the number of moles of sodium carbonate present in 25 cm^3 of the washing soda solution.

(1)

(iii) Hence calculate the total number of moles of sodium carbonate present in 250 cm^3 of the washing soda solution.

(1)

(iv) Calculate the molar mass of the hydrated washing soda, $Na_2CO_3.xH_2O$. Hence deduce the value of x in the sample of washing soda from the data in Method 2.

(2)

x = ...

(h) A student carrying out Method 2 overshot the end-point of each titration.

Explain how this would affect the calculated value of x.

(2)

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(Total for Question 3 = 16 marks)

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4 The thermal decomposition of copper(II) carbonate is

$$CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$$ **Equation 3**

The enthalpy change for this reaction, ΔH_3, cannot be determined directly. However, it can be calculated using Hess's law, from the enthalpy changes for the reaction of sulfuric acid with copper(II) carbonate and with copper(II) oxide.

(a) A student carried out an experiment to determine the enthalpy change, ΔH_4, for the reaction

$$CuCO_3(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l) + CO_2(g)$$ **Equation 4**

In the experiment, a known mass of copper(II) carbonate was mixed with a known volume of sulfuric acid in a polystyrene cup, and the temperature change measured. The results of the experiment are shown in the table.

Measurement	Reading
Mass of copper(II) carbonate added to sulfuric acid	2.54 g
Volume of sulfuric acid, 1 mol dm^{-3}	50.0 cm^3
Initial temperature of sulfuric acid before addition of copper(II) carbonate	24.3°C
Maximum temperature of sulfuric acid after the addition of copper(II) carbonate	29.0°C

(i) Calculate the energy transferred, in joules, for this reaction using the expression

Energy transferred (J) $= 50.0 \times 4.18 \times$ temperature change

(1)

(ii) Calculate the number of moles of copper(II) carbonate used.

Molar mass of copper(II) carbonate = 123.5 g mol^{-1}

(1)

(iii) Use your answers to (a)(i) and (a)(ii) to calculate, in kJ mol^{-1}, the enthalpy change, ΔH_4, for the reaction shown in **Equation 4**. Include a sign for ΔH_4 and give your answer to **three** significant figures.

(2)

(iv) Why does the sulfuric acid need to be in excess?

(1)

....

....

(v) The enthalpy change obtained from this experiment is much less negative than the Data Booklet value.

Suggest one likely reason for this difference, other than a measurement error.

(1)

....

....

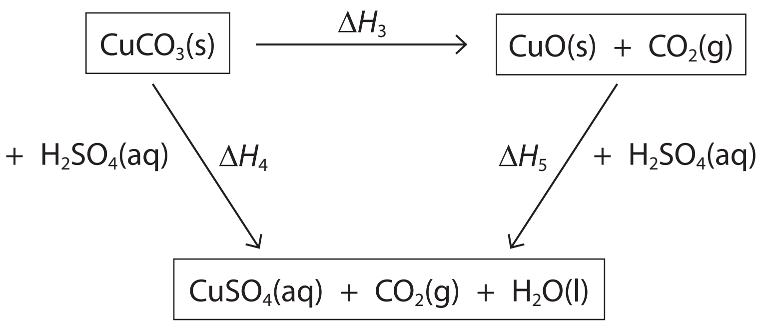
....

(b) The student then carried out a similar experiment to determine the enthalpy change, ΔH_5, for the reaction between copper(II) oxide and sulfuric acid.

$$CuO(s) \quad + \quad H_2SO_4(aq) \quad \rightarrow \quad CuSO_4(aq) \quad + \quad H_2O(l)$$ **Equation 5**

From the results of this experiment, ΔH_5 was calculated to be –56.1 kJ mol^{-1}.

The values of ΔH_4 and ΔH_5 can be used to determine the enthalpy change for the thermal decomposition of copper(II) carbonate using the Hess cycle shown below.



Use Hess's law to calculate the value of ΔH_3, in kJ mol^{-1}. Include a sign in your answer.

(2)

(c) Suggest why it is not possible to determine directly the enthalpy change for the thermal decomposition of copper(II) carbonate.

(1)

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....

....

(Total for Question 4 = 9 marks)

5 A method for the preparation of iodoethane is given in outline below.

Procedure

Step 1 Suitable quantities of red phosphorus and iodine are placed in a round-bottom flask. The flask is fitted with a reflux condenser and immersed in cold water.

Step 2 Using a dropping pipette, a suitable volume of ethanol is added, in 1 cm^3 portions, down the condenser.

Step 3 After the addition of the ethanol is complete, and a further 15 minutes have passed, the cold water bath is removed and the mixture in the flask is heated under reflux for 45 minutes.

Step 4 The apparatus is allowed to cool and the condenser is rearranged for distillation.

Step 5 The crude iodoethane is distilled off.

Step 6 The distillate is washed with dilute sodium carbonate solution.

Step 7 The washed iodoethane is separated from the aqueous solution.

Step 8 Anhydrous calcium chloride is added to the washed iodoethane.

The equations for the reactions are

$$2P + 3I_2 \rightarrow 2PI_3$$

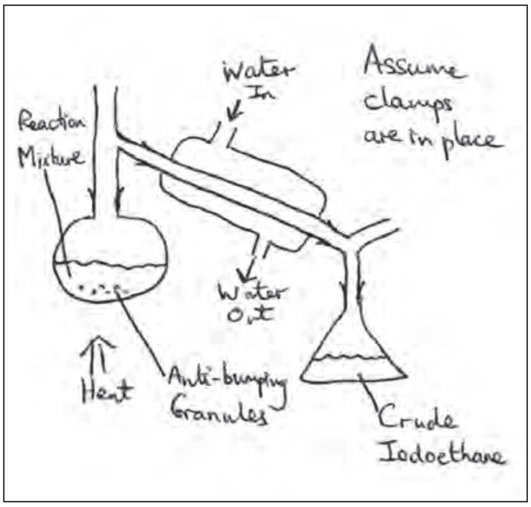
$$3CH_3CH_2OH + PI_3 \rightarrow 3CH_3CH_2I + H_3PO_3$$

(a) What does the way in which ethanol is added in **step 2** suggest about the nature of the reaction?

(1)

....

(b) A student drew a diagram of the apparatus used in **step 5**. There are a number of errors in the diagram.



(i) One of the errors is that the flow of water in the condenser is the wrong way round. Explain the effect of this error.

(1)

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....

(ii) Identify the most significant error in the diagram and explain the effect of this.

(1)

Error ....

Effect ....

....

....

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(c) Suggest why, in **step 6**, the crude iodoethane is washed with dilute sodium carbonate solution.

(1)

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....

(d) Draw a diagram of the apparatus that would be used in **step 7** to separate the iodoethane. Name the apparatus and label its contents.

The density of iodoethane is 1.5 g cm^{-3} and the density of the aqueous solution is about 1.0 g cm^{-3}.

(3)

Name of apparatus..

Diagram

(e) How will the appearance of the iodoethane be changed by the addition of anhydrous calcium chloride in **step 8**?

(1)

....

....

(f) How would the iodoethane be separated from the calcium chloride after **step 8**?

(1)

....

....

(g) To obtain pure iodoethane, one further step in the preparation is needed. What is this step?

(1)

....

(h) It is not possible to effectively produce iodoethane by reacting ethanol with a mixture of sodium iodide and 50% sulfuric acid. This is because the sulfur in the sulfuric acid can be reduced to form substances such as hydrogen sulfide and sulfur.

State what happens to the iodide ions in the sodium iodide when this occurs.

(1)

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(Total for Question 5 = 11 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1	2											3	4	5	6	7	0 (8)
							1.0 **H** hydrogen 1										*(18)* 4.0 **He** helium 2
(1)	*(2)*											*(13)*	*(14)*	*(15)*	*(16)*	*(17)*	
6.9 **Li** lithium 3	9.0 **Be** beryllium 4											10.8 **B** boron 5	12.0 **C** carbon 6	14.0 **N** nitrogen 7	16.0 **O** oxygen 8	19.0 **F** fluorine 9	20.2 **Ne** neon 10
23.0 **Na** sodium 11	24.3 **Mg** magnesium 12	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	27.0 **Al** aluminium 13	28.1 **Si** silicon 14	31.0 **P** phosphorus 15	32.1 **S** sulfur 16	35.5 **Cl** chlorine 17	39.9 **Ar** argon 18
39.1 **K** potassium 19	40.1 **Ca** calcium 20	45.0 **Sc** scandium 21	47.9 **Ti** titanium 22	50.9 **V** vanadium 23	52.0 **Cr** chromium 24	54.9 **Mn** manganese 25	55.8 **Fe** iron 26	58.9 **Co** cobalt 27	58.7 **Ni** nickel 28	63.5 **Cu** copper 29	65.4 **Zn** zinc 30	69.7 **Ga** gallium 31	72.6 **Ge** germanium 32	74.9 **As** arsenic 33	79.0 **Se** selenium 34	79.9 **Br** bromine 35	83.8 **Kr** krypton 36
85.5 **Rb** rubidium 37	87.6 **Sr** strontium 38	88.9 **Y** yttrium 39	91.2 **Zr** zirconium 40	92.9 **Nb** niobium 41	95.9 **Mo** molybdenum 42	[98] **Tc** technetium 43	101.1 **Ru** ruthenium 44	102.9 **Rh** rhodium 45	106.4 **Pd** palladium 46	107.9 **Ag** silver 47	112.4 **Cd** cadmium 48	114.8 **In** indium 49	118.7 **Sn** tin 50	121.8 **Sb** antimony 51	127.6 **Te** tellurium 52	126.9 **I** iodine 53	131.3 **Xe** xenon 54
132.9 **Cs** caesium 55	137.3 **Ba** barium 56	138.9 **La*** lanthanum 57	178.5 **Hf** hafnium 72	180.9 **Ta** tantalum 73	183.8 **W** tungsten 74	186.2 **Re** rhenium 75	190.2 **Os** osmium 76	192.2 **Ir** iridium 77	195.1 **Pt** platinum 78	197.0 **Au** gold 79	200.6 **Hg** mercury 80	204.4 **Tl** thallium 81	207.2 **Pb** lead 82	209.0 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

	140 **Ce** cerium 58	141 **Pr** praseodymium 59	144 **Nd** neodymium 60	[147] **Pm** promethium 61	150 **Sm** samarium 62	152 **Eu** europium 63	157 **Gd** gadolinium 64	159 **Tb** terbium 65	163 **Dy** dysprosium 66	165 **Ho** holmium 67	167 **Er** erbium 68	169 **Tm** thulium 69	173 **Yb** ytterbium 70	175 **Lu** lutetium 71
* Lanthanide series														
* Actinide series	232 **Th** thorium 90	[231] **Pa** protactinium 91	238 **U** uranium 92	[237] **Np** neptunium 93	[242] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[245] **Bk** berkelium 97	[251] **Cf** californium 98	[254] **Es** einsteinium 99	[253] **Fm** fermium 100	[256] **Md** mendelevium 101	[254] **No** nobelium 102	[257] **Lr** lawrencium 103