A Level Chemistry B (Salters)

H433/03 Practical skills in chemistry

Sample Question Paper

Date – Morning/Afternoon

Time allowed: 1 hour 30 minutes

You must have:
- the Insert
- the Data Sheet for Chemistry B (Salters)

You may use:
- a scientific calculator

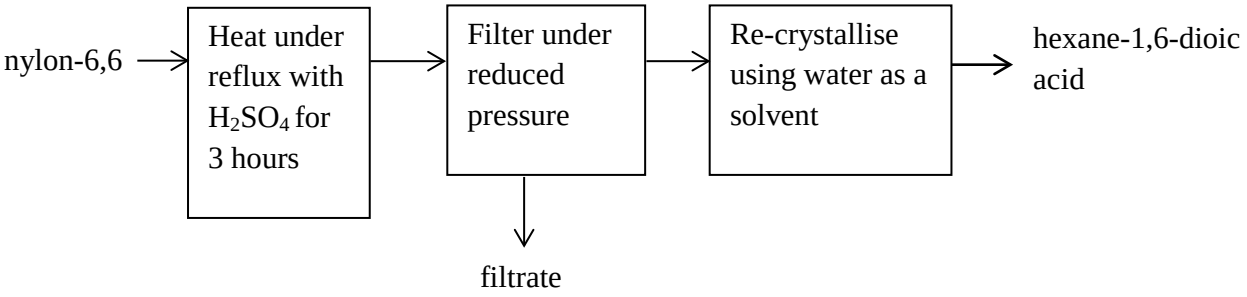
First name									
Last name									
Centre number						**Candidate number**				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **12** pages.

Answer **all** the questions.

1 **(a)** Scientists are investigating how best to recycle polymers including nylon-6,6. One approach is to break the polymer down into its monomers which can be re-used. The following flow chart shows how hexane-1,6-dioic acid can be produced from nylon-6,6.



(i) What is meant by *heating under reflux*?

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…… **[2]**

(ii) Draw a labelled diagram to show how crystals of hexane-1,6-dioic acid can be collected by filtration under reduced pressure.

[3]

(iii) Describe the main steps involved in carrying out the recrystallization of hexane-1,6-dioic acid using water as a solvent.

In your account, describe what property of hexane-1,6-dioic acid this process depends upon.

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…… **[4]**

(iv) 0.40 g of pure hexane-1,6-dioic acid (M_r = 146) are obtained from 2.0 g of nylon-6,6.

Calculate the percentage yield of the reaction.

yield = …… % **[2]**

(b) The student adds excess sodium hydroxide solution to the filtrate. The student notices that the mixture develops a 'fishy' smell characteristic of an amine.

Suggest the shortened structural formula of the compound responsible for the 'fishy' smell.

…… **[1]**

2 (a) A group of students set out to investigate the heating effect of volcanic lava on any carbonate rocks that it may flow over. They decide to devise an experiment to compare the thermal stability of magnesium carbonate and calcium carbonate.

The students have access to magnesium carbonate powder, lumps of calcium carbonate, calcium hydroxide powder, distilled water and whatever apparatus they need.

(i)* Describe how the students could carry out their experiment.

You should include in your answer:

- a labelled diagram of the apparatus used to safely heat the carbonate compounds
- the main steps in the experimental procedure and the names of the key apparatus (not included in the labelled diagram)
- the observations and measurements that should be recorded
- how to ensure the comparison is fair and the results are as accurate as possible.

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…… **[6]**

(ii) The students find that the magnesium carbonate decomposes more readily than calcium carbonate and believe this can be explained by the difference in *charge density* of the magnesium and calcium ions.

What is meant by the term *charge density*?

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…… **[1]**

(iii) Explain, in terms of the charge densities of the cations, the relative thermal stabilities of magnesium carbonate and calcium carbonate.

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…… **[2]**

(iv) The enthalpy change of reaction, $\Delta_r H$, for the decomposition of magnesium carbonate is +118 kJ mol^{-1}.

The entropies for the compounds in this reaction are given in the table below.

	$MgCO_3$	**MgO**	**CO_2**
***S* / J mol^{-1} K^{-1}**	66	27	214

What is the minimum temperature to which the students must heat the magnesium carbonate powder for decomposition to occur?

Include units in your answer.

Show **all** your working.

minimum temperature = …….. **[3]**

(b) The students also investigate the volume of carbon dioxide released when carbonate rocks decompose.

They carry out an experiment in which a known mass of magnesium carbonate is heated and the gas evolved is collected in a 100 cm^3 gas syringe. The apparatus is allowed to cool to room temperature and the volume of the gas collected is measured.

(i) What is the maximum mass of magnesium carbonate that could be used in this experiment?

maximum mass = **……** g **[1]**

(ii) The students repeat the experiment using the same mass of calcium carbonate instead of magnesium carbonate.

Describe and explain how the volume of gas collected will compare to the volume collected when magnesium carbonate was decomposed.

……

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…… **[2]**

3 A student investigates the use of spirit burners as alternative heating sources for laboratories without a gas supply.

A spirit burner containing ethanol is weighed. 100 cm^3 of water are measured into a beaker clamped above the spirit burner. The temperature of the water is recorded. The spirit burner wick is lit and allowed to heat the water. The thermometer is used to stir the water. After about 5 minutes the flame of the burner is extinguished, the maximum temperature reached by the water is recorded and the spirit burner is re-weighed.

The student records the following results.

Mass of spirit burner and ethanol before burning / g	20.33
Mass of spirit burner and ethanol after burning / g	18.92
Initial temperature of the water / °C	17.5
Maximum temperature reached by the water / °C	88.0

(a) (i) The temperatures are measured using a thermometer that has graduation marks at every 1 °C.

Calculate the percentage error associated with the temperature difference in the above results.

Give your answer to **two** significant figures.

percentage error = **……** % **[1]**

(ii) Using the student's results, calculate the enthalpy change of combustion of ethanol.

Assume that the density of water is 1.00 g cm^{-3}.

Show **all** your working.

enthalpy change of combustion = **……** kJ mol^{-1} **[3]**

(b) (i) The student repeats the experiment using a spirit burner containing methanol instead of ethanol. The same mass of fuel is burned in both experiments.

Suggest **two** reasons why the total energy transferred from the spirit burner is different in the two experiments.

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…… **[2]**

(ii) Describe how the student can ensure that the same amount of energy is transferred from the spirit burner in the experiment using methanol as is transferred in the experiment described in **(a)(ii)**.

State the assumption you have made.

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…… **[2]**

(c) At the end of the experiments the student notices that there is a black deposit on the bottom of the beaker.

Suggest what this might be and why it might have been formed.

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…… **[2]**

4 This question refers to the ***Practical Insert*** that is provided as an insert to this paper.

(a) **(i)** Name a suitable piece of apparatus (with its size) that could be used to measure 25 cm^3 of dilute sulfuric acid into the conical flask in **Part 1**.

…… **[1]**

(ii) Suggest **two** reasons why the conical flask in **Part 1** was fitted with a bung carrying a capillary tube, apart from loss of spray.

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…… **[2]**

(iii) Use the student's results in **Part 1** to calculate the percentage of iron in the paper clip.

Show **all** your working.

percentage of iron = …… % **[4]**

(b) (i) In **Part 2**, the student was given a solution labelled '2% Mn'.

Calculate the concentration (in g dm^{-3}) of a solution of potassium manganate(VII) that contains the same concentration of Mn as would be in 100 cm^3 of a solution made from 0.25 g of paper clips if they contained '2% Mn' by mass.

Show **all** your working.

concentration = …… g dm^{-3} **[3]**

(ii) Explain why a '2% Mn' solution made by dissolving potassium manganate(VII) crystals would be more accurate than a '0.5% Mn' solution made using the same method.

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…… **[1]**

(iii)* Describe how the student could use the '2% Mn' solution and a colorimeter to produce a calibration curve suitable for finding the concentration of manganese in the paper clip solution.

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…… **[6]**

(iv) How could the student have improved the line drawn on the calibration graph in **Part 2** without doing further experiments?

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…… **[1]**

(v) Use the line drawn by the student on the calibration graph to read off a value for the % Mn in the paper clip solution.

…….. **[1]**

(c) (i) In which titration could some of the paper clip solution have been spilled from the pipette onto the bench while it was being transferred to the conical flask?

Explain your answer.

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…… **[2]**

(ii) The student suggests that the concentration of the MnO_4^- ions in the solution made from the paper clips could be determined by titrating it against a standard solution of Fe^{2+} ions.

Why would this method **not** give an accurate result?

……

…… **[1]**

(d) Suggest another method, other than using a titration or a colorimeter, that the student could use to find the concentration of Fe^{2+} ions in a solution made from paper clips.

……

…… **[1]**

END OF QUESTION PAPER

A Level Chemistry B (Salters)
H433/03 Practical skills in chemistry
Sample Practical Insert

Date – Morning/Afternoon
Time allowed: 1 hour 30 minutes

INFORMATION FOR CANDIDATES

- This document consists of **4** pages. Any blank pages are indicated.

INSTRUCTIONS TO EXAMS OFFICER/INVIGILATOR

- Do not send this insert for marking; it should be retained in the centre or destroyed.

Iron and manganese in paper clips

A student describes below a project to find the amount of iron and manganese in some paper clips:

- To find the amount of iron in the paper clips, I decided to use a titration with potassium manganate(VII) solution.
- To find the amount of manganese in the paper clips, I found out that I could oxidise it in solution to potassium manganate(VII) and then use a colorimeter because the intensity of the purple colour I get depends on its concentration of MnO_4^- ions.

Part 1: Determination of iron in paper clips

I found the following method in an old book and decided to use it to find the amount of iron in the paper clips.

Determination of the percentage of iron in iron wire

Weigh out accurately about 1.4 g of iron wire and transfer it to a conical flask containing 25 cm^3 of dilute sulfuric acid and a few cm^3 of concentrated sulfuric acid to accelerate the reaction. Fit the flask with a rubber bung containing a short length of capillary tubing.

Warm the flask carefully to maintain a steady reaction and, when all the iron has reacted leaving only particles of carbon, cool the flask. Transfer the solution quantitatively to a 250 cm^3 volumetric flask and make up to the mark with dilute sulfuric acid and water. Pipette 25 cm^3 of this solution into a conical flask, add about 25 cm^3 of dilute sulfuric acid and titrate with standard potassium manganate(VII) solution (about 0.02 mol dm^{-3}).

[Reference: STARK, J G (1971): *Titrimetric analysis for A & S levels SI Edition* London, John Murray, 27]

The reaction of iron with sulfuric acid is:

$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

The half-equations for the titration reaction are:

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$
$Fe^{2+} \rightarrow Fe^{3+} + e^-$

I had to ask what a 'capillary' tube was and was told that it is a glass tube with a small internal diameter.

These are my results:

Mass of paper clips added to the conical flask = 1.28 g
Concentration of manganate(VII) solution = 0.0200 mol dm^{-3}

	Titration 1	**Titration 2**	**Titration 3**	**Titration 4**	**Titration 5**
Final burette reading / cm^3	22.90	45.40	22.55	43.05	24.00
Initial burette reading / cm^3	0.00	22.90	0.00	20.95	1.55

Part 2: Determination of manganese in paper clips

I found a website that said that steel normally contains between 0.1 and 0.4% manganese. I was given the following worksheet that I could follow to find the amount of manganese in the paper clips. It involves reacting pieces of paper clip with nitric acid to produce a solution containing Mn^{2+} ions. The Mn^{2+} are then oxidised with potassium iodate(VII) to MnO_4^- ions.

Method for the determination of manganese in paper clips:

1 Weigh accurately about 0.25 g of cut-up paper clip.
2 Put it into approximately 70 cm^3 of 2.0 mol dm^{-3} nitric(V) acid in a beaker.
3 In a fume cupboard, warm but do not boil the acid to help the paper clip to dissolve. The nitric(V) acid oxidises the manganese to $Mn^{2+}(aq)$ ions.
4 Add about 10 cm^3 of phosphoric(V) acid to the beaker, followed by about 10 cm^3 of potassium iodate(VII) solution. Boil the solution carefully for 10 minutes. Allow the mixture to cool. [The phosphoric(V) acid prevents the precipitation of insoluble iron(III) salts.]
5 When the solution is cool pour it into a 100 cm^3 volumetric flask using a small funnel. It is important not to lose any of the solution. Rinse the remaining solution from the beaker and funnel into the flask with distilled water and add further distilled water to bring the solution in the flask exactly up to the mark.
6 Stopper the flask and shake it to ensure that the solution is uniform. All the manganese that was in the 0.25 g of paper clip is now in the purple solution as the manganate(VII) ion, $MnO_4^-(aq)$.

(Reference: DENBY, Derek, OTTER, Chris, STEPHENSON, Kay (eds) (2009), *Salters Advanced Chemistry Support Pack*, Heinemann, 71)

I was given a solution of MnO_4^- ions, labelled '2% Mn', which had the same concentration as one that would be produced in my experiment from 0.25 g of steel containing 2% manganese by mass. The solution was actually made up by dissolving potassium manganate(VII) crystals in distilled water in a 1 dm^3 volumetric flask. Starting with this solution, I produced the calibration curve (**Fig. 1**) using a colorimeter. I would have preferred to start with a '0.5% Mn' solution, but my teacher said that it wouldn't be as accurate as the '2% Mn' solution.

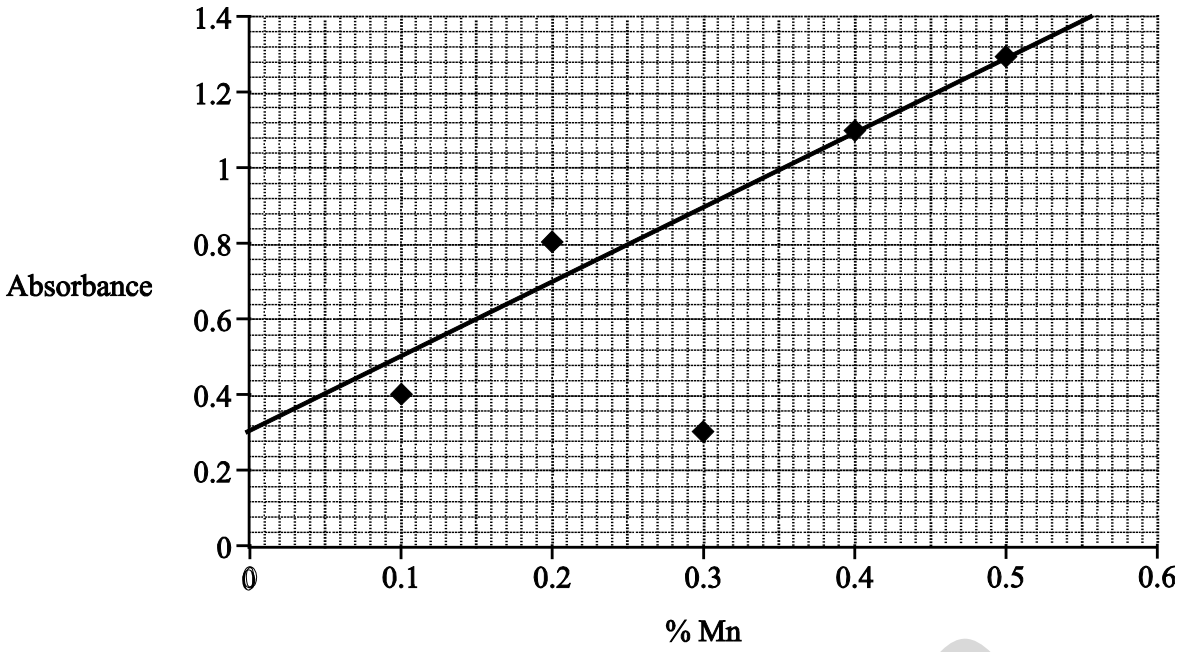

Fig. 1 % Mn against absorbance

The solution that I made from the paper clips gave an absorbance reading on the colorimeter of 0.64.

Comments on my experiments

I thought that my experiments went well. During the titration I had a bit of a problem with the pipette filler and I think I spilled some of the paper clip solution onto the bench as I was transferring it to the conical flask in one of my titrations.

One extra thing I could have done was to check the concentration of the MnO_4^- ions in the solution that I made from the paper clips by titrating it against a standard solution of Fe^{2+} ions.

END OF PRACTICAL INSERT