AQA A-Level Chemistry: Practice Paper 4

Focus: Practical Skills

Difficulty: Hard

Time: 2 hours 15 minutes

Marks: 100 marks

Grade Boundaries: (approximate)

A*: 80 (80%)

A: 70 (70%)

B: 60 (60%)

C: 50 (50%)

D: 40 (40%)

Main Topics Examined:

Titrations, Organic Synthesis, Chemical Tests, Apparatus

Advice:

1. Read the questions carefully - look out for tricks.
2. Some questions are harder than the A-level standard.
3. Apply existing knowledge to unfamiliar questions.
4. Check the fully worked solutions for any questions you missed.

1. Read the following instructions that describe how to make up a standard solution of a solid in a volumetric flask.

"Take a clean 250 cm^3 volumetric flask. Use the balance provided and a clean, dry container, to weigh out the amount of solid required. Tip the solid into a clean, dry 250 cm^3 beaker and add about 100 cm^3 of distilled water. Use a stirring rod to help the solid dissolve, carefully breaking up any lumps of solid with the rod. When the solid has dissolved, pour the solution into the flask using a filter funnel. Add water to the flask until the level rises to the graduation mark."

a. i) Suggest **three** further instructions that would improve the overall technique in this account. [3 marks]

ii) In a series of titrations using the solution made up in part (a), a student obtained the following titres (all in cm^3).

Rough	1	2
25.7	25.20	25.35

State what this student must do in order to obtain an accurate average titre in this experiment. [2 marks]

b. The correct technique can improve the accuracy of a titration.

i) State why it is important to fill the space below the tap in the burette with the known solution before beginning an accurate titration. [1 mark]

ii) Suggest **one** reason why a 250 cm^3 conical flask is preferred to a 250 cm^3 beaker for a titration. [1 mark]

iii) During a titration, a chemist rinsed the inside of the conical flask with deionised water. The water used for rinsing remained in the conical flask.

Give **one** reason why this rinsing can improve the accuracy of the end-point, and explain why the water used for rinsing has no effect on the accuracy of the titre. [2 marks]

iv) Suggest one reason why repeating a titration makes the value of the average titre more reliable. [1 mark]

c. The maximum errors for the pipette and burette are ± 0.05 cm^3 and ± 0.15 cm^3 respectively. Estimate the maximum percentage error in each of the pieces of apparatus when used with an average titre of 24.25 cm^3.

[2 marks]

[Total for Q1: 12 marks]

2. A student carried out an experiment to determine the number of C=C double bonds in a molecule of a cooking oil by measuring the volume of bromine water decolourised. The student followed these instructions:

- Use a dropping pipette to add 5 drops of oil to 5.0 cm^3 of inert organic solvent in a conical flask.
- Use a funnel to fill a burette with bromine water.
- Add bromine water from a burette to the solution in the conical flask and swirl the flask after each addition to measure the volume of bromine water that is decolourised.

The student's results are shown in the table below.

Experiment	Volume of bromine water / cm^3
1	39.40
2	43.50
3	41.20

a. In a trial experiment, the student failed to fill the burette correctly so that the gap between the tap and the tip of the burette still contained air.

Suggest what effect this would have on the measured volume of bromine water in this trial. Explain your answer. [2 marks]

b. Other than incorrect use of the burette, suggest a reason for the inconsistency in the student's results. [1 mark]

c. Outline how the student could improve this practical procedure to determine the number of C=C double bonds in a molecule of the oil so that more consistent results are obtained. [4 marks]

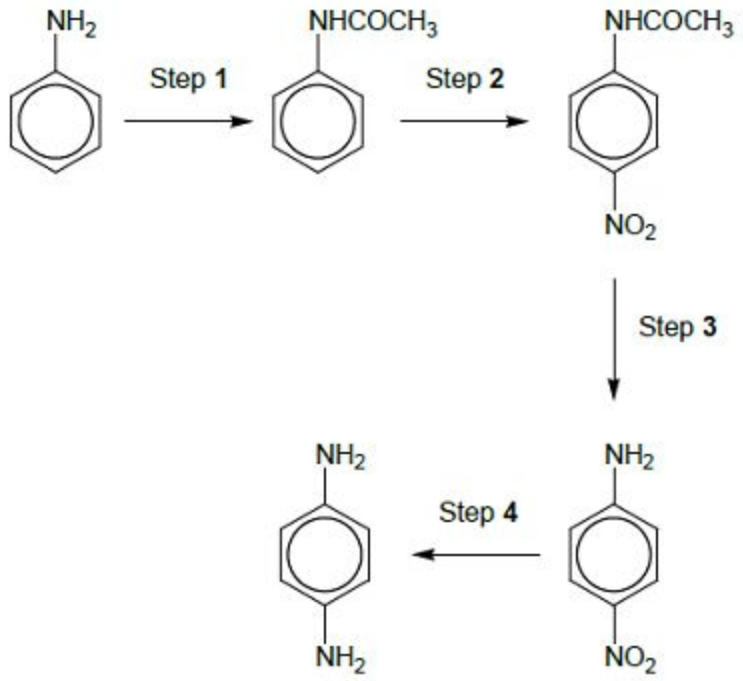
d. The oil has a density of 0.92 g cm^{-3} and each of the 5 drops of oil has a volume of 5.0×10^{-2} cm^3. The approximate M_r of the oil is 885. The concentration of bromine water used was 2.0×10^{-2} mol dm^{-3}.

Use these data and the results from experiment **1** to deduce the number of C=C double bonds in a molecule of the oil. Show your working. [5 marks]

[Total for Q2: 12 marks]

3. 1,4-diaminobenzene is an important intermediate in the production of polymers such as Kevlar and also of polyurethanes, used in making foam seating.

A possible synthesis of 1,4-diaminobenzene from phenylamine is shown in the following figure.



a. Identify a suitable reagent to carry out Step **1**, and name and draw the mechanism that occurs in this reaction. [5 marks]

b. The product of step **1** was purified by recrystallisation as follows.

The crude product was dissolved in **the minimum quantity of hot water** and the hot solution was filtered through a hot filter funnel into a conical flask. This filtration removed any insoluble impurities. The flask was **left to cool to room temperature**. The crystals formed were filtered off using a Buchner funnel and a clean cork was used **to compress the crystals in the funnel. A little cold water was then poured through the crystals.** After a few minutes, the crystals were removed from the funnel and weighed. A small sample was then used to find the melting point.

Give reasons for each of the following practical steps (outlined in **bold** above):

i) The minimum quantity of hot water was used [1 mark]

ii) The flask cooled to room temperature before the crystals were filtered off [1 mark]

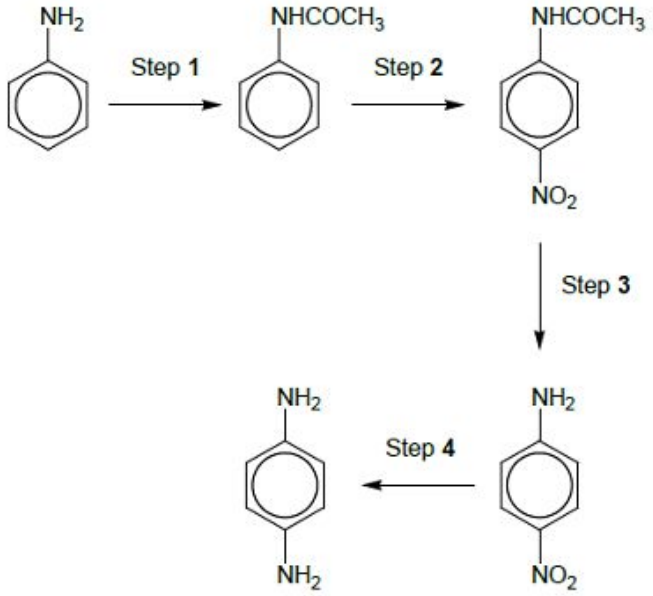
iii) The crystals were compressed in the funnel [1 mark]

iv) A little cold water was poured through the crystals [1 mark]

c. The melting point of the sample in part (b) was found to be slightly lower than a data-book value.

Suggest the most likely impurity to have caused this low value and an improvement to the method so that a more accurate value for the melting point would be obtained. [2 marks]

d. The reaction scheme from above is repeated to help you.



In an experiment starting with 5.05 g of phenylamine, 4.82 g of purified product were obtained in step **1**.

Calculate the percentage yield in this reaction. Give your answer to the appropriate number of significant figures. [3 marks]

e. A reagent for step **2** is a mixture of concentrated nitric acid and concentrated sulfuric acid, which react together to form a reactive intermediate.

i) Write an equation for the **reaction** of this intermediate in Step **2**. [1 mark]

ii) Name a mechanism for the reaction in Step **2**. [1 mark]

f. Suggest the type of reaction occurring in Step **3**. [1 mark]

g. Identify the reagents used in Step **4**. [1 mark]

[Total for Q3: 18 marks]

4. This question is about the chemical properties of chlorine, sodium chloride and sodium bromide.

a. Sodium bromide reacts with concentrated sulfuric acid in a different way from sodium chloride.

Write an equation for this reaction of sodium bromide and explain why bromide ions react differently from chloride ions. [3 marks]

b. A colourless solution contains a mixture of sodium chloride and sodium bromide. Using aqueous silver nitrate and any other reagents of your choice, develop a procedure to prepare a pure sample of silver bromide from this mixture. Explain each step in the procedure and illustrate your explanations with equations, where appropriate. [6 marks]

c. Write an ionic equation for the reaction between chlorine and cold dilute sodium hydroxide solution. Give the oxidation state of chlorine in each of the chlorine-containing ions formed. [2 marks]

[Total for Q4: 11 marks]

5. A laboratory technician discovered four badly−labelled bottles, each containing one pure white solid. Each bottle contained a compound of a different Group 2 metal (magnesium, calcium, strontium and barium).

Some tests were carried out on the solids or, if the compound was soluble, on the aqueous solution. The results are given in the table.

Test	Compound 1	Compound 2	Compound 3	Compound 4
Added to water	Dissolves	Insoluble	Dissolves	Dissolves
Solution or solid added to HCl(aq)	Solution remains colourless	Gives off carbon dioxide gas and a colourless solution forms	Solution remains colourless	Solution remains colourless and heat released
Solution or solid added to NaOH(aq)	Solution gives a white precipitate	Solid remains insoluble	Solution gives a slight white precipitate	Solution has no visible change
Solution or solid added to H_2SO_4(aq)	Solution has no visible change	Gives off carbon dioxide gas and a white solid remains	Solution slowly forms a slight white precipitate	Solution forms a white precipitate

a. One of the bottles has a very faint label that could be read as “Magnesium Sulfate”.

Use the information in the table to deduce which **one** of the four compounds is magnesium sulfate and explain your answer. [3 marks]

b. The bottle containing **Compound 2** has a 'TOXIC' hazard symbol.

Use the information in the table to identify **Compound 2** and explain both observations of its reaction with H_2SO_4 (aq). [3 marks]

c. Identify which compound is strontium hydroxide and give an equation for its reaction with sulfuric acid. [2 marks]

[Total for Q5: 8 marks]

6. The table below shows observations of changes from some test-tube reactions of aqueous solutions of compounds **Q**, **R** and **S** with five different aqueous reagents. The initial colours of the solutions are not given.

	$BaCl_2$ + HCl	**$AgNO_3$ + HNO_3**	**NaOH**	**Na_2CO_3**	**HCl (conc)**
Q	no change observed	pale cream precipitate	white precipitate	white precipitate	no change observed
R	no change observed	white precipitate	white precipitate, dissolves in excess of NaOH	white precipitate, bubbles of a gas	no change observed
S	white precipitate	no change observed	brown precipitate	brown precipitate, bubbles of a gas	yellow solution

a. Identify each of the compounds **Q**, **R** and **S**.
You are not required to explain your answers. [6 marks]

Q is

R is

S is

b. Write ionic equations for each of the positive observations with **S**. [4 marks]

[Total for Q6: 10 marks]

7. When a solution containing iron(II) ions is treated with a slight excess of a solution containing ethanedioate ions, a bright yellow precipitate of hydrated iron(II) ethanedioate, $FeC_2O_4.2H_2O$, is formed. The precipitate is filtered off, washed with propanone and then allowed to dry. A typical yield of the solid is 95%.

a. i) Propanone boils at 56 °C and is miscible with water in all proportions. Suggest **two** reasons why washing with propanone is an effective method for producing a pure, dry precipitate. [2 marks]

ii) By suggesting a simple test tube reaction, state how the filtrate could be tested to show that all of the iron(II) ions have been removed from the solution. State what you would observe. [2 marks]

iii) Suggest **one** reason why the typical yield of iron(II) ethanedioate is less than 100%. [1 mark]

iv) Calculate the mass of hydrated iron(II) ethanedioate, $FeC_2O_4 . 2H_2O$ that can be formed from 50.0 cm^3 of a 0.50 mol dm^{-3} solution of iron(II) sulfate when the yield of the reaction is 95%. Show your working. [3 marks]

v) The identity of the precipitate can be confirmed by dissolving it in sulfuric acid and titrating the mixture with potassium manganate(VII).

Deduce the number of moles of iron(II) ethanedioate that would react with one mole of potassium manganate(VII) in acidic solution.

[1 mark]

b. Ethanedioate ions can be used to remove calcium ions from blood plasma. A precipitate of calcium ethanedioate is formed.

Write an ionic equation for the reaction of ethanedioate ions with calcium ions.

[1 mark]

c. Ethanedioic acid is used to clean marble, a form of calcium carbonate. Suggest **one** reason why the reaction between ethanedioic acid and marble stops after a short time. [1 mark]

d. Tea leaves contain ethanedioic acid. Suggest **one** reason why tea drinkers do **not** suffer from ethanedioic acid poisoning. [1 mark]

e. Ethanedioic acid is produced by the oxidation of carbon monoxide in a multi-step process. The equation which summarises the reactions taking place is

$$4\ CO + 4\ NaOH + O_2 + 4\ HCl \rightarrow 2\ H_2C_2O_4 + 4\ NaCl + 2\ H_2O$$

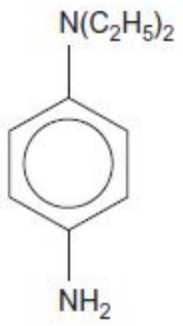
Calculate the percentage atom economy for the formation of ethanedioic acid in this reaction. Show your working. [2 marks]

[Total for Q7: 14 marks]

8. Chlorine can be found in water. One method for the determination of chlorine in water is to use colorimetry.

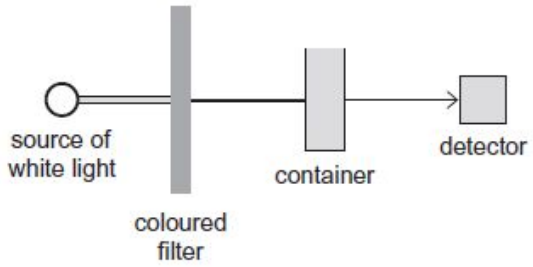
A colourless sample of water from a vase of flowers was analysed after the addition of compound **W** which resulted in a purple solution.

Compound W



a. Determine the percentage by mass of nitrogen in **W**. [2 marks]

b. A simplified diagram of a colorimeter is shown below:



i) Suggest why it is important that the container for each sample has the same dimensions. [1 mark]

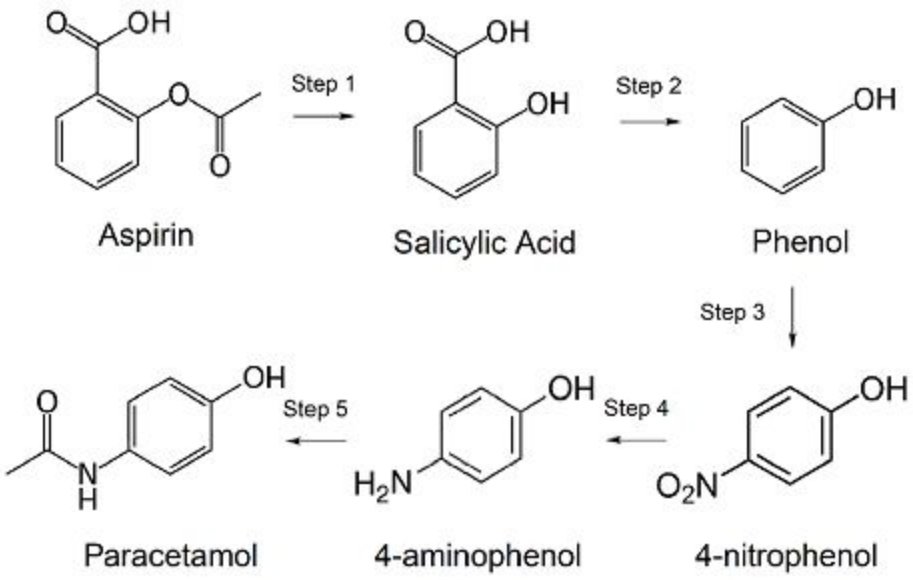
ii) Suggest why the coloured filter is used. [1 mark]

iii) Suggest one reason why a colorimetric method might be chosen in preference to a titration. [1 mark]

[Total for Q8: 5 marks]

9. Aspirin and Paracetamol are common remedies for colds and fevers.

A pharmacologist proposes a scheme to convert aspirin to paracetamol through four organic intermediates:



Outline reagents and suitable apparatus where appropriate to carry out each step of this reaction scheme and obtain a pure paracetamol product. Name the type of reaction occuring in steps 1, 3, 4 and 5.

You are given that Step 2 may be performed by heating to form the phenol and a gaseous waste product. You are **not** required to outline a full experimental procedure. [10 marks]

[Total for Q9: 10 marks]

Question Sources:

Q1,2,3,4,5,6,7,8: AQA A-Level Chemistry Past Paper