Core practicals

The core practicals are an integral part of your course. They are not there to get you to demonstrate some text book 'fact' or recall some simple information. They are there to help you develop the whole range of practical and mathematical skills which are essential to chemists and which will be tested in the written assessments.

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Questions on core practicals

1. Measuring the molar volume of a gas

Greg is doing an experiment to find the molar volume of gas.

He puts 50 cm^3 of 1.0 mol dm^{-3} hydrochloric acid in a flask. The flask has a bung, with a delivery tube connected to a gas syringe.

Greg plans to add 0.40 g of calcium carbonate to the hydrochloric acid in the flask, quickly insert the bung, and measure the volume of gas collected.

(a) Write a chemical equation, including state symbols, for the reaction that takes place.

(b) Show, by calculation, that the HCl is in excess.

(c) Which piece of apparatus should Greg use to measure out the hydrochloric acid? Give a reason for your answer.

(d) Comment on the mass of $CaCO_3$ that the student plans to use.

(e) Greg does not place the bung tightly into the flask as the reaction takes place and some gas is lost. What affect will this have on his calculation of the molar mass of the gas?

2. Preparation of a standard solution from a solid acid

Kathryn prepares a standard solution of sodium hydrogensulfate by weighing 0.900 g of the solid into a beaker. She adds approximately 25 cm^3 of distilled water and stirs with a glass rod until the solid dissolves. She uses a funnel to transfer this solution into a 250 cm^3 volumetric flask.

Finally, she rinses the beaker and the glass rod with distilled water, adds this to the flask, and makes up to the mark with distilled water.

(a) Describe the process of 'making up to the mark'.

(b) What next step should Kathryn take before using this standard solution for a titration?

(c) Calculate the concentration of this standard solution of sodium hydrogensulfate. Give your answer to an appropriate number of significant figures.

(d) Another student repeats Kathryn's method, but does not rinse the beaker and glass rod. Their teacher estimates that 0.5 cm^3 of solution remains in the beaker and on the glass rod. Use this information to estimate the percentage error introduced into this experiment by failing to rinse the apparatus.

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3. Finding the concentration of a solution of hydrochloric acid

Ahmed wants to check the concentration of a sample of concentrated hydrochloric acid.

He uses a 10.0 cm^3 pipette to transfer a sample of the concentrated acid to a 250 cm^3 volumetric flask. He makes up the solution to the mark with distilled water and mixes thoroughly.

He then fills a clean burette with a standardised solution of 0.350 mol dm^{-3} sodium hydroxide solution.

Ahmed uses a suitably rinsed pipette to transfer 25.0 cm^3 of the diluted hydrochloric acid to a conical flask. He titrates this with the sodium hydroxide solution, using an indicator.

The table shows his data.

	1st titration	**2nd titration**	**3rd titration**
Final burette reading / cm^3	24.60	48.85	24.35
Initial burette reading / cm^3	0.00	24.60	0.00

(a) Ahmed uses a 'suitably rinsed' pipette. What does this mean?

(b) Ahmed wants to choose an indicator to use in this titration.

(i) Give a reason why UI is not used in titrations.

(ii) Give the name of an indicator that Ahmed could use, stating the colour change he would see at the end point.

(c) Ahmed calculates that his average titre value is 24.30 cm^3. Show how he arrived at this answer.

(d) Use Ahmed's data to calculate the original concentration of the concentrated hydrochloric acid.

[Hint: you will need to work out the amount, in moles, of HCl using the mean titre value, and therefore the amount present in the 100 cm^3 volumetric flask. Lastly, you need to relate this answer to the original concentration of the HCl]

4. Investigation of the rates of hydrolysis of halogenoalkanes

Rosemary investigates the rate of hydrolysis of 1-chlorobutane, 1-bromobutane and 1-iodobutane.

She takes 1.0 cm^3 of each halogenoalkane, dissolves this in ethanol, and adds 2 cm^3 of silver nitrate solution. She times the time taken for a precipitate to form.

(a) Does taking equal volumes of the three halogenoalkanes increase the validity of Rosemary's experiment? Explain your answer.

(b) What colour precipitate will Rosemary record in each experiment?

(c) Rosemary's results table is shown below.

1-chlorobutane	5mins 12 s
1-bromobutane	104 s
1-iodopropane	14.65 s

Criticise the way in which this data is recorded.

(d) Rosemary suggested extending her investigation by using 1-chlorobutane, 2-bromobutane and 2-iodo-2-methylpropane. Comment on this suggestion.

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5. The oxidation of ethanol

Jason prepares ethanal by adding ethanol, slowly, to a hot solution of acidified potassium dichromate(VI) solution. He distils off the ethanal as it forms.

(a) Why is it important that the ethanol is added slowly to the hot oxidising agent?

(b) Jason distils off the ethanal as it forms, rather than heating the ethanol and the oxidising agent together under reflux. Explain why.

(c) Ethanal boils at 21°C. How does this information influence the way in which ethanal is collected in this experiment?

(d) Describe how Jason could show that the product:

(i) contained ethanal

(ii) was pure.

6. Chlorination of 2-methylpropan-2-ol with concentrated hydrochloric acid

Hazel has been asked to convert butan-2-ol into 2-chlorobutane. She places 10 cm^3 of butan-2-ol into a separating funnel, and adds an equal volume of concentrated hydrochloric acid. She puts a stopper in the separating funnel and shakes it for 5 minutes.

She leaves the mixture to settle, then uses the separating funnel to separate the aqueous layer, containing the hydrochloric acid, from the organic layer, containing the 2-chlorobutane.

(a) Explain one safety precaution that Hazel should take in this experiment.

(b) Draw a labelled diagram of the separating funnel after the shaken mixture has settled, indicating the nature of the layers.
[densities in g cm^{-3}: 2-chlorobutane = 1.397, butan-2-ol = 0.808, concentrated HCl = 1.18]

(c) Hazel leaves the stopper in the separating funnel when she tries to separate the layers. Describe what will happen.

(d) Describe how a pure sample of 2-chlorobutane can be extracted from the organic layer.

(e) Hazel collects 2.64g of 2-chlorobutane. Calculate the percentage yield.

7. Analysis of some inorganic and organic unknowns

Cliff has four bottles labelled A, B, C and D. He knows that the substances are NaCl, NaI, K_2CO_3 and K_2SO_4.

(a) Describe chemical tests, with their results, that Cliff can do to distinguish between these solids.

(b) When testing for halide ions, a little nitric acid is added to the test solution before the silver nitrate solution. Explain why.

(c) An organic liquid has the formula C_3H_6O. The liquid decolourises bromine water; and reacts with PCl_5 to produce misty fumes. Identify the functional groups present and hence draw a possible structural formula for the liquid.

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8. To determine the enthalpy change of a reaction using Hess's Law

Assie wants to find $\Delta_r H$ for the reaction: $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

She decides to react solid calcium carbonate and solid calcium oxide, separately, with dilute hydrochloric acid; and find $\Delta_r H$ using Hess' Law.

(a) Draw a suitable Hess's Law cycle. Use ΔH_1 to show the enthalpy change for the reaction of calcium carbonate with dilute HCl(aq) and ΔH_2 to show the enthalpy change for the reaction of calcium oxide with dilute HCl(aq).

(b) Many enthalpy change reactions are performed in polystyrene cup. How does this help the accuracy of the experiment?

(c) In the reaction between calcium carbonate and dilute HCl(aq), Assie uses 1.00 g of $CaCO_3$, and 25.0 cm^3 of 1.0 mol dm^{-3} HCl (an excess). She measures a temperature change of +5.6°C.

(i) Calculate the heat energy released in this experiment.

(ii) Hence, calculate the enthalpy change, in kJ mol^{-1} of calcium carbonate.

(iii) Estimate the overall measurement uncertainty in Assie's experiment, stating your assumptions.

9. Finding the K_a value for a weak acid

Bosun is investigating the weak acid, propanoic acid. He places 25.0 cm^3 of propanoic acid into a conical flask and measures its pH using a pH meter.

He adds 2.0 cm^3 of sodium hydroxide solution, of a similar concentration, from a burette, swirls the flask and measures the pH again. He repeats this procedure, plotting the pH against the volume of sodium hydroxide added on a graph as he continues.

Bosun wants to use the data to calculate the K_a value of propanoic acid.

(a) Describe how Bosun should use his results to find K_a.

(b) Bosun's method has a major flaw. Identify this flaw and explain how Bosun can alter this experiment to avoid it.

(c) The electrode of a pH meter is usually stored in a buffer solution. Explain why this is important in an experiment such as this.

(d) Bosun finds that $K_a = 1.349 \times 10^{-5}$ mol dm^{-3}. The acid has an initial pH of 2.58. Calculate the concentration of the acid.

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10. Investigating some electrochemical cells

Helen sets up an electrochemical cell, consisting of a copper electrode in a 1 mol dm^{-3} solution of copper(II) sulfate and a zinc electrode in a 1 mol dm^{-3} solution of zinc(II) sulfate.

Helen connects the two cells with a salt bridge, made from a strip of filter paper soaked in potassium nitrate solution.

(a) Why is a salt bridge necessary in this experiment?

(b) Why is potassium nitrate solution used in the salt bridge?

(c) When Helen connects her voltmeter to the electrodes, it reads -1.10 V, instead of +1.10V. Give a reason why.

(d) Helen's friend sets up a similar experiment, with the same apparatus, but with a different solution of copper(II) sulfate. She records a value of +1.05 V. Give a reason why this difference has occurred.

11. Redox titration

Rhubarb leaves are toxic, because they contain ethanedioic acid, $(COOH)_2$. Ethanedioic acid can be oxidised to produce carbon dioxide and water:

$$(COOH)_2 \rightarrow 2CO_2 + 2H^+ + 2e$$

Richard wants to find how much ethanedioic acid is in a rhubarb leaf. He chops up a rhubarb leaf and leaves it in hot water for 10 minutes. He transfers the liquid into a 250 cm^3 volumetric flask, with washings, makes up to the mark, and mixes the solution.

He titrates 25.0 cm^3 of the rhubarb leaf solution against 0.00200 mol dm^{-3} potassium manganate(VII) solution. 10.50 cm^3 is needed for complete reaction.

(a) What practical problems are often encountered when using potassium manganate(VII) solution in a burette?

(b) It is common to add the first 1 cm^3 or so of potassium manganate(VII), wait for it to react, and then proceed more quickly with the titration. Give a reason why this procedure is used.

(c) Explain why this titration does not need an indicator.

(d) Calculate the mass of ethanedioic acid in the rhubarb leaf.

[Molar mass of ethanedioic acid = 90 g mol^{-1}]

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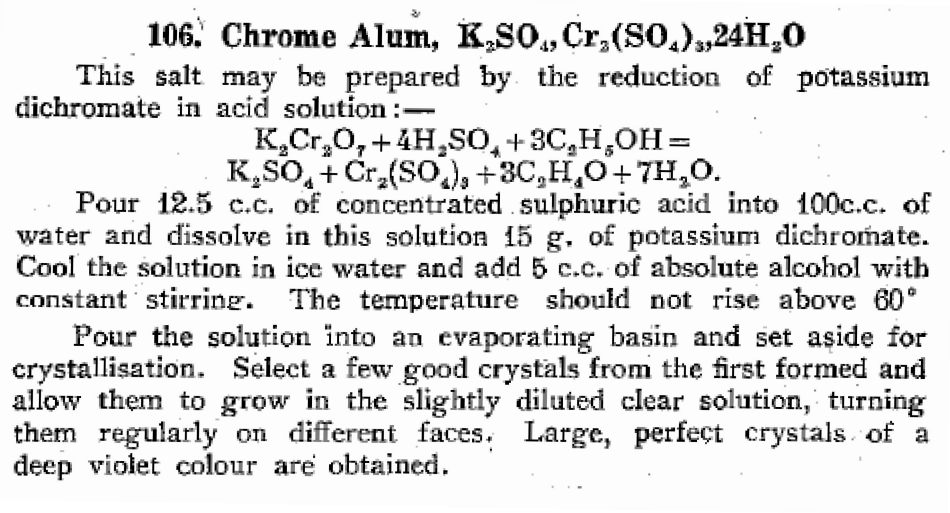
12. The preparation of a transition metal complex

Damian has found instructions for the preparation of chrome alum in an old chemistry book. Chrome alum is a double salt of potassium sulfate and chromium sulfate, with the formula $K_2SO_4.Cr_2(SO_4)_3.24H_2O$.



106. Chrome Alum, $K_2SO_4,Cr_2(SO_4)_3,24H_2O$

This salt may be prepared by the reduction of potassium dichromate in acid solution:—

$$K_2Cr_2O_7 + 4H_2SO_4 + 3C_2H_5OH = K_2SO_4 + Cr_2(SO_4)_3 + 3C_2H_4O + 7H_2O.$$

Pour 12.5 c.c. of concentrated sulphuric acid into 100c.c. of water and dissolve in this solution 15 g. of potassium dichromate. Cool the solution in ice water and add 5 c.c. of absolute alcohol with constant stirring. The temperature should not rise above 60°

Pour the solution into an evaporating basin and set aside for crystallisation. Select a few good crystals from the first formed and allow them to grow in the slightly diluted clear solution, turning them regularly on different faces. Large, perfect crystals of a deep violet colour are obtained.

(a) What is the oxidation state of chromium in chrome alum?

(b) In the first step of the reaction, concentrated sulfuric acid is added to water in order to dilute the acid. Suggest why the dilution of sulfuric acid is not performed by adding water to the acid.

(c) Use information in the passage to describe the heat energy change that occurs when ethanol (*absolute alcohol*) is added to the acidified solution of potassium dichromate.

(d) What is the maximum mass of chrome alum that can be made from 15 g of potassium dichromate?

13. Following the rate of the iodine-propanone reaction by a titrimetric method and investigating a 'clock reaction' (Harcourt-Esson, iodine clock)

John investigates the kinetics of the oxidation of glucose by acidified potassium manganate(VII) solution, $KMnO_4(aq)$. His method is:

1. Measured volumes of glucose solution, sulfuric acid and water are added to a conical flask.
2. A measured volume of potassium manganate(VII) solution is added to the flask. The mixture is gently swirled and a stopwatch started.
3. The time taken for the mixture in the flask to change colour is recorded and the initial rate of the reaction is then calculated.
4. The experiment is repeated using different volumes of the solutions.

continued

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John collects these results:

Exp't	Glucose / cm^3	Sulfuric acid / cm^3	$KMnO_4(aq)$ / cm^3	Water / cm^3	Initial rate / mol dm^{-3} s^{-1}
A	20.0	20.0	10.0	0.0	1.0×10^{-5}
B	20.0	20.0	5.0	5.0	5.0×10^{-6}
C	10.0	20.0	10.0	10.0	9.8×10^{-6}
D	10.0	10.0	10.0	20.0	4.9×10^{-6}

(a) Give the name of the piece of apparatus that should be used to measure the volumes used in each experiment. Justify your choice.

(b) What colour change would you see in step 3?

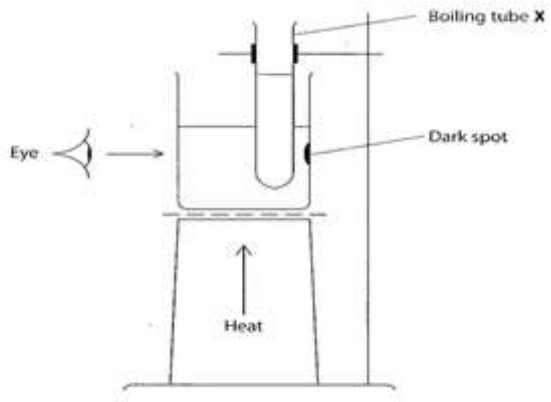
(c) Explain why water is added to the flask in experiments B, C and D.

(d) Suggest a technique that could be used to monitor the change in potassium manganate(VII) concentration during the reaction.

(e) State the order with respect to glucose, sulfuric acid and potassium manganate(VII) and hence write the rate equation for the reaction.

14. Finding the activation energy of a reaction

Henna uses this apparatus to investigate the activation energy of the reaction between sodium thiosulfate and hydrochloric acid.



She does the reaction at four temperatures. Her results table is shown below.

Experiment	Temperature / °C	Temperature / K	1 ÷ T / K^{-1}	ln (rate constant)
A	60.0	333.0		−1.60
B	49.5	322.5		−2.60
C	38.5	311.5		−3.75
D	25.5	298.5		−5.20

(a) How does Henna know when each reaction is complete?

(b) Complete the table.

(c) Plot a graph of ln (rate constant) against 1 ÷ temperature and calculate the gradient of this graph.

(d) Use your answer to (c) to calculate the activation energy, *E*a, for this reaction. Include a sign and units in your answer.

Gradient = $-\frac{Ea}{R}$ where R = 8.31 J K^{-1} mol^{-1}

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15. Analysis of some inorganic and organic unknowns

Three compounds **A**, **B** and **C** are subjected to a series of chemical tests. The three compounds are isomers with molecular formula C_3H_6O.

A and **B** contain only one functional group, but **C** contains two separate functional groups. None of the three compounds contains a ring of atoms. In each of the three compounds the oxygen atom is bonded to only one carbon atom.

(a) **A** and **B** are tested separately with 2,4-dinitrophenylhydrazine solution and both give an orange precipitate. When **A** and **B** are heated separately with a mixture of potassium dichromate(VI) and dilute sulfuric acid, the solution containing **B** turns from orange to green. The solution containing **A** remains orange. Use these results and the information at the start of the question to deduce displayed formulae for **A** and **B**.

(b) The melting point of the orange solid formed when A reacts with the solution of 2,4-dinitrophenylhydrazine should be 126 °C. Describe how the melting point of a small sample of this solid can be determined.

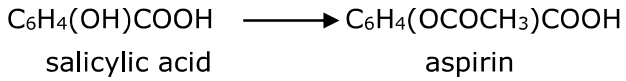
(c) In a different experiment, a student is asked to identify the two cations present in a solution, **D**. The solution is green.

(i) State the inference that the student can make about the solution.

(ii) The student adds dilute ammonia solution to a sample of **D**. He sees a precipitate, which appears to be dark brown. When he adds more ammonia solution, the amount of precipitate decreases and a deep blue solution is formed. He filters the mixture. The remaining precipitate is red-brown. Use this information to identify the two cations present in **D**. Justify your answers.

16. The preparation of aspirin

In an experiment to prepare aspirin, salicylic acid is reacted with excess ethanoic anhydride.



(a) Calculate the maximum mass of aspirin that could be obtained from 2.00 g of salicylic acid.
[molar masses / g mol^{-1}: salicylic acid = 138; aspirin = 180]

(b) In a preparation a student prepares 1.45 g of aspirin from 2.00 g of salicylic acid. Calculate the percentage yield.

(c) Give two reasons why the yield in the preparation is less than 100%.

(d) The sample of aspirin can be purified through the process of recrystallisation. The impure aspirin is dissolved in a minimum quantity of hot solvent. This solution is cooled and the pure aspirin crystals are separated by vacuum filtration and washed with a small amount of cold solvent. The aspirin is then dried.

(i) Explain why the aspirin is dissolved in the minimum quantity of hot solvent.

(ii) Explain what happens to the impurities when the hot solution cools.

(iii) Describe how you could show that the final aspirin sample was pure.

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