The results provided here are typical results.

Core Practical 1

Results

The results being discussed are for sodium chloride.

1 Typical results for sodium chloride:

Temperature of water (°C)	Solubility (g per 100 g of solvent)
10	33
20	35
30	36
40	37

Analysis

1 The graph should be a curve. For sodium chloride, the curve is very shallow and goes up as temperature increases.

2 The solubility of sodium chloride in water increases as the temperature of the water increases.

Evaluation

1 Comment about the direction of the curve from left to right. The general direction of the graphs should be the same – increasing as temperature increases. Be careful about scales on the y-axis; a different scale may give a different shape.

2 To improve accuracy, experiments could be repeated at a particular temperature to obtain a mean result. Further temperatures could also be investigated. Temperatures within the results already obtained should fit closely into the solubility curve already drawn. Temperatures investigated outside the current results should still fit the general pattern of increasing temperature leading to increasing solubility.

Core Practical 2

Results

1 Distance between baseline and solvent front (cm) = 9.4 cm

Ink colour 1	black			
Colour of dye spots	yellow	blue	brown	red
Distance of spot from baseline (cm)	4.2	6.3	3.6	7.8
R_f value	0.45	0.67	0.38	0.83

Ink colour 2	green			
Colour of dye spots	blue	yellow		
Distance of spot from baseline (cm)	6.3	4.2		
R_f value	0.67	0.45		

Analysis

1 Use the equation to calculate the R_f value. The R_f values you calculate cannot be above 1. If they are, then check your calculation. A value of 0 means that the ink/dye has not moved and so the solvent chosen is likely incorrect.

2 This depends on your results. You need to look for any inks which did not separate into a number of colours, i.e. where the ink remained as one main dot. Remember, the inks must have moved.

3 Again, this depends on your results. However, similar coloured dyes (in the same location) on your chromatography paper are likely to contain the same chemical compound.

Evaluation

1 The graphite from the pencil will not dissolve in the solvent (water) and so will not interfere with the results. The line will also help when working out the R_f values, as there will be a clear point to take measurements from.

2 This was done so that you could easily recall which pen/original colour of ink was used to produce each spot of ink.

3 The water rises up the paper, and dissolves the dyes.

4 This was done to stop the dyes washing out of the paper.

5 The answer will depend on how clear the top level of each dye is on your chromatograms. If it is difficult to identify the top of each dye accurately, then the accuracy and reliability (how reliable something is) of the calculated R_f values will be reduced.

Core Practical 3, part 1

Results

1 Typical results using approximately 15 cm piece of magnesium:

Mass of empty crucible and lid (g)	24.10
Mass of crucible, lid and magnesium (g)	24.70
Mass of crucible, lid and magnesium oxide after several minutes (g)	25.10
Mass of crucible, lid and magnesium oxide after further 2 minutes (g)	25.10
Mass of crucible, lid and magnesium oxide after further 2 minutes (g)	25.10
Highest mass of crucible, lid and magnesium oxide found (g)	25.10

Analysis

1 Mass of magnesium used = 0.60 g

2 Mass of magnesium oxide formed = 1.00 g

3 Mass of oxygen that has reacted = 0.40 g

4 Example calculation using typical results from above:

Element	magnesium	oxygen
Chemical symbol	Mg	O
Mass reacted in experiment (g)	0.60	0.40
Relative atomic mass (A_r)	24	16
Divide the mass of each element by its A_r	0.60 ÷ 24 = 0.025	0.40 ÷ 16 = 0.025
Divide both answers by the smaller of the two to find the simplest ratio	0.025 ÷ 0.025 = 1	0.025 ÷ 0.025 = 1
Find the simplest whole number ratio	1	1

5 The empirical formula of magnesium oxide is MgO.

Evaluation

1 To allow air/oxygen in so that the magnesium can burn. The lid is only lifted occasionally, otherwise too much magnesium oxide will escape.

2 When it no longer flared up when the lid was lifted.

3 The results should all be similar as the magnesium ribbon length was the same. How well you and other students followed the instructions will determine how close you would get to the actual empirical formula of MgO.

Core Practical 3, part 2

Results

1 Typical results using approximately 3 g of copper oxide:

Mass of empty reduction tube (g)	33.78
Mass of reduction tube and copper(II) oxide (g)	36.96
Mass of reduction tube and copper (g)	36.32

Analysis

1 Mass of copper oxide used = 3.18 g
2 Mass of copper formed = 2.54 g
3 Mass of oxygen that has reacted = 0.64 g
4 Example calculation using typical results from above:

Elements	copper	oxygen
Chemical symbol	Cu	O
Mass found in experiment (g)	2.54	0.64
Relative atomic mass (A_r)	63.5	16
Divide the mass of each element by its A_r	2.54 ÷ 63.5 = 0.04	0.64 ÷ 16 = 0.04
Divide both answers by the smaller of the two to find the simplest ratio	0.04 ÷ 0.04 = 1	0.04 ÷ 0.04 = 1
Find the simplest whole number ratio	1	1

5 The empirical formula of copper(II) oxide is: CuO
6 It changes from black which is copper(II) oxide to pink-brown which is copper. This colour change has occurred as the copper has been reduced.

Evaluation

1 The solid is copper and it would have started to react with oxygen in the air. The copper would have increased in mass when forming copper oxide.

Core Practical 4

Results

1 Expected observations are shown in the table:

Solution	Anode (positive) electrode		Cathode (negative) electrode	
	Observations	Identity of product	Observations	Identity of product
copper(II) sulfate	fizzing, negative damp litmus test, relit glowing splint	oxygen	brown solid deposited on electrodes	copper
sodium chloride	fizzing, positive damp litmus test	chlorine	fizzing, negative damp litmus test, lit splint burns with squeaky pop	hydrogen
sulfuric acid	fizzing, negative damp litmus test, relit glowing splint	oxygen	fizzing, negative damp litmus test, lit splint burns with squeaky pop	hydrogen

Analysis

1 Your own comparisons.
2 Hydrogen gas: use a lit wooden splint/spill, it should go out with a squeaky pop.

   Oxygen gas: use a glowing wooden splint/spill, it should relight.
3 If the solution contains a metal that is higher than hydrogen in the reactivity series, hydrogen is formed. If the metal is lower than hydrogen, that metal is formed.
4 If the solution is a chloride, then chlorine is formed. If the solution is a sulfate, oxygen is formed.

Core Practical 5

Results

1 Expected observations are shown below:

Height of air in test tube at start of experiment (mm)	62
Height of air in test tube at end of experiment (mm)	50
Decrease in height of air in test tube (mm)	12

Analysis

1 $\dfrac{12 \text{ mm}}{62 \text{ mm}} \times 100 = 19.35\%$

   percentage of oxygen in air = 19.35%

Evaluation

1 Your own comments about your results.
2 Being vertical could prevent the upward movement of water in the test tube.
3 Not all of the iron reacted; it might have been too compacted so some of the iron could not react with the oxygen in the air.

Core Practical 6

Results

1 Expected observations are shown in the table:

Metal	Reaction with hydrochloric acid	Reaction with sulfuric acid
calcium	lots of effervescence, beaker gets hot	lots of effervescence and then reaction slows quickly
aluminium	reaction starts slowly then speeds up, some effervescence	reaction starts slowly then speeds up, some effervescence
copper	no reaction	no reaction
iron	very few bubbles seen	very few bubbles seen
magnesium	lots of effervescence, test tube gets hot	lots of effervescence, test tube gets hot
zinc	some effervescence seen	some effervescence seen

Analysis

1 calcium

   magnesium

   aluminium

   zinc

   iron

   copper
2 The reaction between calcium and sulfuric acid starts quickly but slows down. This is because of the formation of a coating of insoluble calcium sulfate around the metal.

3 The reaction starts off very slowly but should speed up as the aluminium oxide coating is removed and the acid can react with the aluminium.

4 $Ca + 2HCl \rightarrow CaCl_2 + H_2$

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

Core Practical 7

Results

1 Your own result.

2 The crystals are blue and diamond-shaped. (The size will vary depending on the conditions.)

3 **a** clear solution

   b black solid (powder)

   c blue solution

4 Your own percentage yield calculated using the following equation:

$$\frac{\text{actual yield (g)}}{\text{theoretical yield (g)}} \times 100 = \text{percentage yield}$$

Analysis

1 copper oxide + sulfuric acid → copper sulfate + water

2 So that all the acid is used up.

3 The acid would react with the excess copper oxide and some or all of the copper oxide would disappear.

4 Copper oxide.

5 Copper sulfate.

6 Because the hydrogen ions of the acid react and a salt and water are formed.

7 Copper oxide.

8 $CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$

Core Practical 8

Results

1 white solid/powder

Analysis

1 lead(II) nitrate + sodium sulfate → lead(II) sulfate + sodium nitrate

2 $Pb(NO_3)_2 + Na_2SO_4 \rightarrow PbSO_4 + 2NaNO_3$

3 $Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$

4 Na^+ and NO_3^-

Evaluation

1 You could lose some of the solid you want.

Core Practical 9, part 1

Results

1 Typical results for 1.0 M sodium hydroxide and 1.0 M hydrochloric acid:

Volume of sodium hydroxide solution added (cm³)	Maximum temperature recorded at each stage (°C)		
	Experiment 1	Experiment 2	Mean
0	22.1	22.3	22.20
5	23.2	23.8	23.50
10	23.5	24.1	23.80
15	23.8	24.3	24.05
20	24.4	24.8	24.60
25	25.3	25.8	25.55
30	26.4	26.8	26.60
35	24.4	24.9	24.65
40	23.6	24.4	24.00

Analysis

1 Your own graph should show an inverted (other way round) 'V' shape with the 'point' at the top.

2 Your own lines of best fit.

3 This should be the volume of sodium hydroxide at the point of the crossing over of the lines. The volume of hydrochloric acid will be 30 cm³ (as this is its initial volume and does not change).

4 At this point, no reaction is taking place. The acid is used up and sodium hydroxide is now in excess. It is this excess, colder, sodium hydroxide that lowers the temperature.

5 Here is a typical set of results using the volumes used in the experiment:

concentration of HCl = 1.0 mol/dm³

volume of HCl = 30 cm³

volume of NaOH = 40 cm³

temperature change (ΔT) = +4.4 °C

The calculation for these results is as follows:

$n(HCl) = 0.030 \text{ dm}^3 \times 1.0 \text{ mol/dm}^3 = 0.030 \text{ mol}$

$Q = 70 \text{ g} \times 4.2 \text{ J/g/°C} \times +4.4 \text{ °C} = +1293.6 \text{ J}$

$\Delta H = -(+1293.6 \text{ J} \div 0.030 \text{ mol}) = -43,120 \text{ J/mol} = -43 \text{ kJ/mol}$

(to 2 sf)

The negative value means that this reaction is exothermic.

6 Comment on your value. Often the value is close to the data book value as the reaction is fast and hence the heat energy transfer to the surroundings in minimal.

Evaluation

1 Use a digital temperature sensor so the reading can be easily seen going up and down. (It would also have the benefit of increasing precision.)

2 Select the region where the lines cross over and read off the sodium hydroxide volume from the graph. Using this value as a guide, repeat the investigation but instead of adding 5 cm³ each time, add 1 cm³ volumes to cover approximately 5 cm³ either side of the sodium hydroxide value recorded as the maximum.

Core Practical 9, part 2

Results

1 Typical results for this experiment:

	Experiment 1	Experiment 2	Mean
Starting temperature (°C)	21.8	22.0	21.9
Lowest final temperature (°C)	20.0	20.2	20.1

Analysis

1 A typical set of results using the volumes used in the experiment:

mass = 90 g

temperature change (ΔT) = −1.8 °C

$Q = 90 \text{ g} \times 4.2 \text{ J/g/°C} \times -1.8 \text{ °C} = -680 \text{ J}$

$\Delta H = -(-680 \text{ J} \div 0.050 \text{ mol}) = +13\,600 \text{ J/mol} = +14 \text{ kJ/mol (to 2 sf)}$

The positive value means that this reaction is endothermic.

2 Comment on your value. Often the value obtained is close to the data book value. As the ammonium chloride usually dissolves very quickly, heat energy transfer from the surroundings to the solution is kept to a minimum.

Core Practical 9, part 3

Results

1 Typical results for various alcohols, you may be supplied with additional alcohols not listed:

| Time (seconds) | Maximum temperature recorded at each stage (°C) | | | | |
	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Mean
0 (start)	22	22	22	23	22.25
30	22	22	22	22	22.00
60	22	23	22	22	22.25
90	22	22	22	22	22.00
120	22	22	22	22	22.00
150	22	23	22	22	22.25
180 (zinc added)	22	22	22	22	22.00
210	47	57	57	58	54.75
240	56	67	64	67	63.50
270	58	67	67	67	64.75
300	62	66	66	66	65.00
360	61	65	65	64	63.75
420	60	64	64	63	62.75

Analysis

1 A typical results graph would look like the one shown in question 2, but without the extra lines, just the plotted points.

2 The temperature change is the difference between the temperature value at the upper, extrapolated, point of the top line at time = 3 min minus the temperature value of the lower line at time = 3 min.

3 A typical set of results using the volumes used in the experiment:

temperature change = 71.0 °C − 22.0 °C = 49.0 °C

Q = 25 g × 4.2 J/g/°C × +49.0 °C = 5145 J

ΔH = − (5145 J ÷ 0.025 mol) = −205 800 J/mol = −206 kJ/mol (to 3 sf)

The negative value means that this experiment is exothermic.

4 Comment on your value. Often the value is close to the data book value. As the ammonium chloride usually dissolves very quickly, so heat energy transfer from the surroundings to the solution is kept to a minimum.

Core Practical 9, part 4

Results

1 Typical results for various alcohols, you may be supplied with additional alcohols not listed:

Alcohol	Mass of burner + lid at start (g)	Mass of burner + lid at end (g)	Temperature of water at start (°C)	Temperature of water at start (°C)
ethanol CH_3CH_2OH	109.80	109.13	22	63
propan-1-ol $CH_3CH_2CH_2OH$	110.10	109.56	21	62
butan-1-ol $CH_3CH_2CH_2CH_2OH$	114.44	114.00	22	64
pentan-1-ol $CH_3CH_2CH_2CH_2CH_2OH$	124.43	124.11	22	66

2 Typical results for 1.0 M copper sulfate:

Alcohol	Mass of alcohol burnt (g)	Temperature rise in water (°C)
ethanol CH_3CH_2OH	0.67	41
propan-1-ol $CH_3CH_2CH_2OH$	0.54	41
butan-1-ol $CH_3CH_2CH_2CH_2OH$	0.44	42
pentan-1-ol $CH_3CH_2CH_2CH_2CH_2OH$	0.32	44

Analysis

1 Calculation using typical results from above:

Alcohol	Energy release from 1 g of fuel
ethanol CH_3CH_2OH	$\dfrac{100g \times 41°C \times 4.2\,J/g°C}{0.67g}$ = 25, 702 J/25.7 kJ
propan-1-ol $CH_3CH_2CH_2OH$	$\dfrac{100g \times 41°C \times 4.2\,J/g°C}{0.54g}$ = 31, 889 J/31.8 kJ
butan-1-ol $CH_3CH_2CH_2CH_2OH$	$\dfrac{100g \times 42°C \times 4.2\,J/g°C}{0.44g}$ = 40, 091 J/40.1 kJ
pentan-1-ol $CH_3CH_2CH_2CH_2CH_2OH$	$\dfrac{100g \times 44°C \times 4.2\,J/g°C}{0.32g}$ = 57, 750 J/57.8 kJ

2 The results should show that the mass of alcohol needed to produce a 1 °C rise in temperature decreases down the group of alcohols (as the number of carbon atoms in the alcohol increases).

Evaluation

1 Any from:
- loss of heat to surroundings (this is the main source of error)
- heat transferred by heating up equipment, measuring temperatures
- measuring mass of water
- measuring mass of alcohol burned
- evaporation of alcohol and evaporation of water
- difficulty in having the same height of flame from each spirit burner
- incomplete combustion of the alcohol

Core Practical 10, part 1

Results

1 Typical results for 1.0 M hydrochloric acid. There may be quite a variation in your results as descriptions of marble chips are vague at best:

Time (min)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Volume of gas (cm³) for small chips	0	22	30	32	34	36	38	39	40	40	40
Volume of gas (cm³) for large chips	0	8	14	20	25	31	34	37	38	39	40

Analysis

1 If results are good, the graph should show two curves rising steadily and levelling off at about the same point. The curve for the small chips should rise and level off more quickly.

2 The reactions were finished when the graph levelled off.

3 For a fixed mass of chips, the smaller the chips, the larger the surface area (or the surface area to volume ratio).

4 The larger the surface area (or the surface area to volume ratio), the faster the reaction.

5 The graph for larger surface area to volume ratio (smaller chips) rises more quickly at the start and levels off more quickly. Therefore, the larger the surface area, the faster the reaction.

Core Practical 10, part 2

Results

1 Typical results when using small marble chips:

Concentration of acid (mol/dm³)	1.0	0.8	0.6	0.4	0.2
Volume of gas produced in 1 minute (cm³)	40	32	24	16	8

Analysis

1 If the results are good, the graph should show a straight line rising steadily as the concentration increases.

2 The higher the concentration of the acid, the more gas is produced and so the rate of the reaction is greater.

3 The graph for volume of gas produced in 1 minute against concentration rises steadily. Therefore, the higher the concentration, the faster the reaction.

Evaluation

1 Possible sources of error are: measuring the volume of gas (which is difficult because of the bubbles in the measuring cylinder), and making sure the marble chips are all the same size. (Other answers are possible.)

2 Measure the volume of gas produced for a longer time, or measure larger volumes of gas. (Other answers are possible.)

Core Practical 11

Results

1 Typical results for this experiment:

Solid	Observation when added to hydrogen peroxide	Mass of filter paper (g)	Mass of filter paper and dry residue (g)	Mass of dry residue (g)
copper(II) oxide	very few bubbles	0.7	1.7	1.0
copper turnings	nothing happens	0.7	1.7	1.0
manganese(IV) oxide	vigorous reaction, bubbles rising to top of boiling tube	0.7	1.7	1.0
potassium iodide	vigorous reaction, bubbles rising to top of boiling tube	0.7	1.7	1.0

Analysis

1 Typical observations expected for this experiment:

Solid	Did the reaction rate increase?	Did the mass change?	Is it a catalyst?
copper(II) oxide	slightly	no	yes
copper turnings	no	no	no
manganese(IV) oxide	yes	no	yes
potassium iodide	yes	no	yes

2 Effectiveness is measured by how vigorous the reaction is. Manganese(IV) oxide produces the most vigorous decomposition, although potassium iodide is very similar; copper(II) oxide is less good as hardly any bubbles were produced. Copper turnings did not act as a catalyst.

Evaluation

1 To make the test fair because changing these variables could affect the amount of bubbles produced.

2 The volume of hydrogen peroxide was accurate. If you measured out exactly 1.0 g of the substances you were testing, this would also be accurate.

3 The gas could be collected either underwater, for example, the same as the way gas was collected in CP10. Alternatively, you could use a gas syringe.
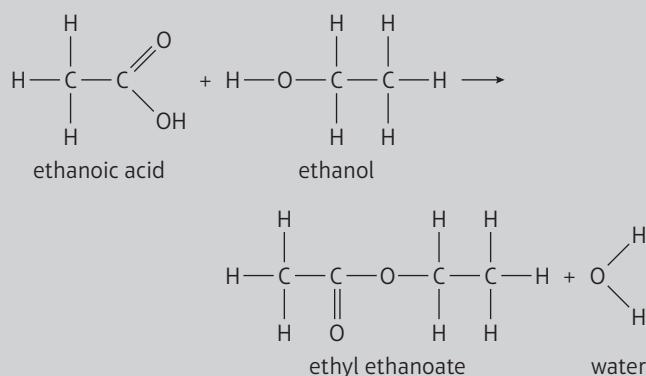
Core Practical 12

Results

1 Expected observations for this experiment:

Name of alcohol	Name of carboxylic acid	Ester produced	Smell of ester
ethanol	ethanoic acid	ethyl ethanoate	sweet smelling

Analysis

1 ethanol + ethanoic acid → ethyl ethanoate + water

2

3 To neutralise the acids.

4 Most organic reactions are slow since they involve the breaking of strong covalent bonds. The proportion of molecular collisions that have the necessary activation energy is usually low at the safe temperature at which the experiment is carried out.

5 It is a catalyst for the reaction.

6 Ethanol is flammable, so using a water bath prevents it igniting.

7 Using a water bath limits the temperature the reaction is carried out at. This will lead to a slower rate of reaction compared to the temperature that can be reached using a Bunsen burner.