Name: _____ Reg: _____

CfE Higher Chemistry

Unit Three – Chemistry In Society

Homework Booklet

For multiple choice questions circle your answer.

Reference may be made to the Chemistry Higher and Advanced Higher Data Booklet.

1) Getting the most from reactants - Part One (Revision)

1. Calculate the gram formula mass of the following substances

a) oxygen (O_2)

b) magnesium nitrate ($Mg(NO_3)_2$)

c) aluminium oxide (Al_2O_3)

2. Calculate the number of moles in the following

a) 4g of calcium carbonate ($CaCO_3$)

b) 80g of sulfur dioxide (SO_2)

c) 100cm^3 of 0.5$mol.l^{-1}$ sodium nitrate solution ($NaNO_3$)

d) 25cm^3 of 1.2 $mol.l^{-1}$ copper (II) chloride solution ($CuCl_2$)

3. Calculate the mass of the following

a) 0.5 moles of water (H_2O)

b) 10 moles of zinc chloride ($ZnCl_2$)

c) sodium chloride (NaCl) crystals to make 25cm^3 of 2$mol.l^{-1}$ solution

d) potassium hydroxide (KOH) granules to make 2 litres of 0.5$mol.l^{-1}$ solution

4. $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

In an experiment 4.9 g of magnesium reacted with excess dilute hydrochloric acid. Calculate the mass of hydrogen produced in this reaction.

2

[I2.Q4b.2007]

5. $3Ag_2S(aq) + 2Al(s) \longrightarrow 6Ag(s) + Al_2S_3(aq)$

Calculate the mass of silver produced when 0.135 g of aluminium is used up.

2

[I2.Q11a.2008]

6. The equation below shows the breakdown of glyceryl tristearate to form glycerol and stearic acid.

$$\underset{\text{glyceryl tristearate}}{C_{57}H_{110}O_6} + \underset{\text{water}}{3H_2O} \longrightarrow \underset{\text{glycerol}}{C_3H_8O_3} + \underset{\text{stearic acid}}{3C_{18}H_{36}O_2}$$

GFM = 890 g

Calculate the mass of stearic acid produced from 8·9 g of glyceryl tristearate.

2

[I2.Q12c.2013]

2) Getting the most from reactants - Part Two
Calculations involving masses

1. 0·5 mol of copper(II) chloride and 0·5 mol of copper(II) sulphate are dissolved together in water and made up to 500 cm^3 of solution.

What is the concentration of $Cu^{2+}(aq)$ ions in the solution in mol l^{-1}?

A 0.5

B 1.0

C 2.0

D 4.0. [Q3.2010]

2. 1 mol of hydrogen gas and 1 mol of iodine vapour were mixed and allowed to react.

After t seconds, 0·8 mol of hydrogen remained.

The number of moles of hydrogen iodide formed at t seconds was

A 0.2

B 0.4

C 0.8

D 1.6. [Q5.2010]

3. Calcium carbonate reacts with nitric acid as follows.

$$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + H_2O(\ell) + CO_2(g)$$

0·05 mol of calcium carbonate was added to a solution containing 0·08 mol of nitric acid. Which of the following statements is true?

A 0·05 mol of carbon dioxide is produced.

B 0·08 mol of calcium nitrate is produced.

C Calcium carbonate is in excess by 0·01 mol.

D Nitric acid is in excess by 0·03 mol. [Q7. 2012]

4. A mixture of sodium bromide and sodium sulfate is known to contain 5 moles of sodium and 2 moles of bromide ions.

How many moles of sulfate ions are present?

A 1·5

B 2·0

C 2·5

D 3·0. [Q3.2010]

5. A mixture of magnesium bromide and magnesium sulphate is known to contain 3 mol of magnesium and 4 mol of bromide ions.

How many moles of sulphate ions are present?

A 1

B 2

C 3

D 4. [Q20. R2013]

6. In the lab, methanamide can be prepared by the reaction of methanoic acid with ammonia.

$HCOOH$	+	NH_3	$\rightleftharpoons$	$HCONH_2$	+	H_2O
mass of one mole = 46·0 g		mass of one mole = 17·0 g		mass of one mole = 45·0 g		mass of one mole = 18·0 g

(a) Calculate the atom economy for the production of methanamide.

1

[10b.R2012*]

(b) When 1·38 g of methanoic acid was reacted with excess ammonia, 0·945 g of methanamide was produced.

Calculate the percentage yield of methanamide.

Show your working clearly.

2

[10c.R2012]

7. Sulfur trioxide can be prepared in the laboratory by the reaction of sulfur dioxide with oxygen.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Under certain conditions, 43·2 tonnes of sulphur trioxide are produced in the reaction of 51·2 tonnes of sulphur dioxide with excess oxygen.

Calculate the percentage yield of sulphur trioxide.

Show your working clearly.

2

[10b.2010]

8. The overall equation for the fermentation of glucose is

$$\underset{\text{mass of one mole} = 180\,g}{C_6H_{12}O_6} \rightarrow \underset{\text{mass of one mole} = 46\,g}{2C_2H_5OH} + 2CO_2$$

(a) Calculate the atom economy for the production of ethanol.

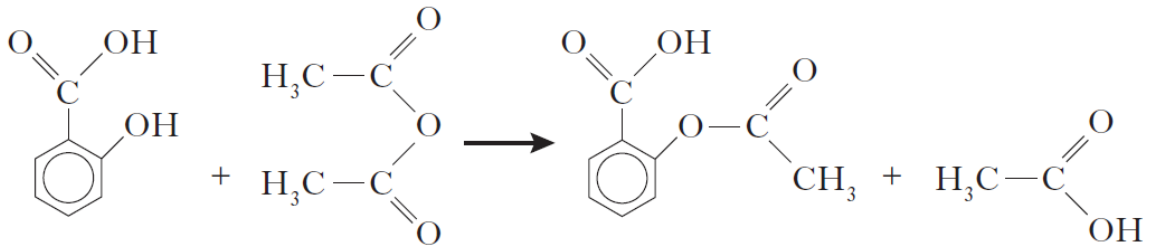
1

(b) Calculate the percentage yield of ethanol if 445 g of ethanol is produced from 1·0 kg of glucose.
Show your working clearly

3

[2a.R2014]

9. Aspirin, a common painkiller, can be made by the reaction of salicylic acid with ethanoic anhydride.



$C_7H_6O_3$	$C_4H_6O_3$	$C_9H_8O_4$	$C_2H_4O_2$
salicylic acid	ethanoic anhydride	aspirin	ethanoic acid

(a) Calculate the atom economy for the production of aspirin.

2

(b) In a laboratory preparation of aspirin, 5·02 g of salicylic acid produced 2·62 g of aspirin.
Calculate the percentage yield of aspirin.
Show your working clearly.

2

[11c.2013]

3) Getting the most from reactants - Part Three
Calculations involving Gases

1. Which of the following gases has the same volume as 128·2 g of sulfur dioxide?
(All volumes are measured under the same conditions of temperature and pressure)

A 2·0 g hydrogen
B 8·0 g helium
C 32·0 g oxygen
D 80·8 g of neon. [Q19.R2014]

2.
$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

How many litres of nitrogen dioxide gas could theoretically be obtained in the reaction of 1 litre of nitrogen monoxide gas with 2 litres of oxygen gas?
(All volumes are measured under the same conditions of temperature and pressure.)

A 1
B 2
C 3
D 4. [Q20.R2012]

3.
$$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(\ell)$$
ethyne

What volume of gas would be produced by the complete combustion of 100 cm^3 of ethyne gas?
All volumes were measured at atmospheric pressure and room temperature.

A 200 cm^3
B 300 cm^3
C 400 cm^3
D 800 cm^3. [Q21.R2013]

4. In which reaction is the volume of products less than the volume of reactants?

A $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
B $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$
C $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$
D $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

[Q21.R2011]

5. A student obtained a certain volume of carbon dioxide by the reaction of 20 cm^3 of 2 mol l^{-1} hydrochloric acid with excess sodium carbonate.

$$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + CO_2(g)$$

Which solution of sulfuric acid would give the same final volume of carbon dioxide when added to excess sodium carbonate?

$$H_2SO_4(aq) + Na_2CO_3(aq) \rightarrow Na_2SO_4(aq) + CO_2(g)$$

A 10 cm^3 of 2 mol l^{-1} sulfuric acid

B 20 cm^3 of 2 mol l^{-1} sulfuric acid

C 10 cm^3 of 4 mol l^{-1} sulfuric acid

D 20 cm^3 of 4 mol l^{-1} sulfuric acid. [Q22.R2011]

6. Argon is a very useful gas and each year 750 000 tonnes of argon are extracted from liquid air.

Air contains 1·3% argon by mass. Calculate the mass of liquid air needed to obtain 750 000 tonnes of argon.

1

[Q1c(ii).R2014]

7. A chemical explosion is the result of a very rapid reaction that generates a large quantity of heat energy and, usually, a large quantity of gas.

The explosive RDX, $C_3H_6N_6O_6$, is used in the controlled demolition of disused buildings.

During the reaction it decomposes as shown.

$$C_3H_6O_6N_6(s) \rightarrow 3CO(g) + 3H_2O(g) + 3N_2(g)$$

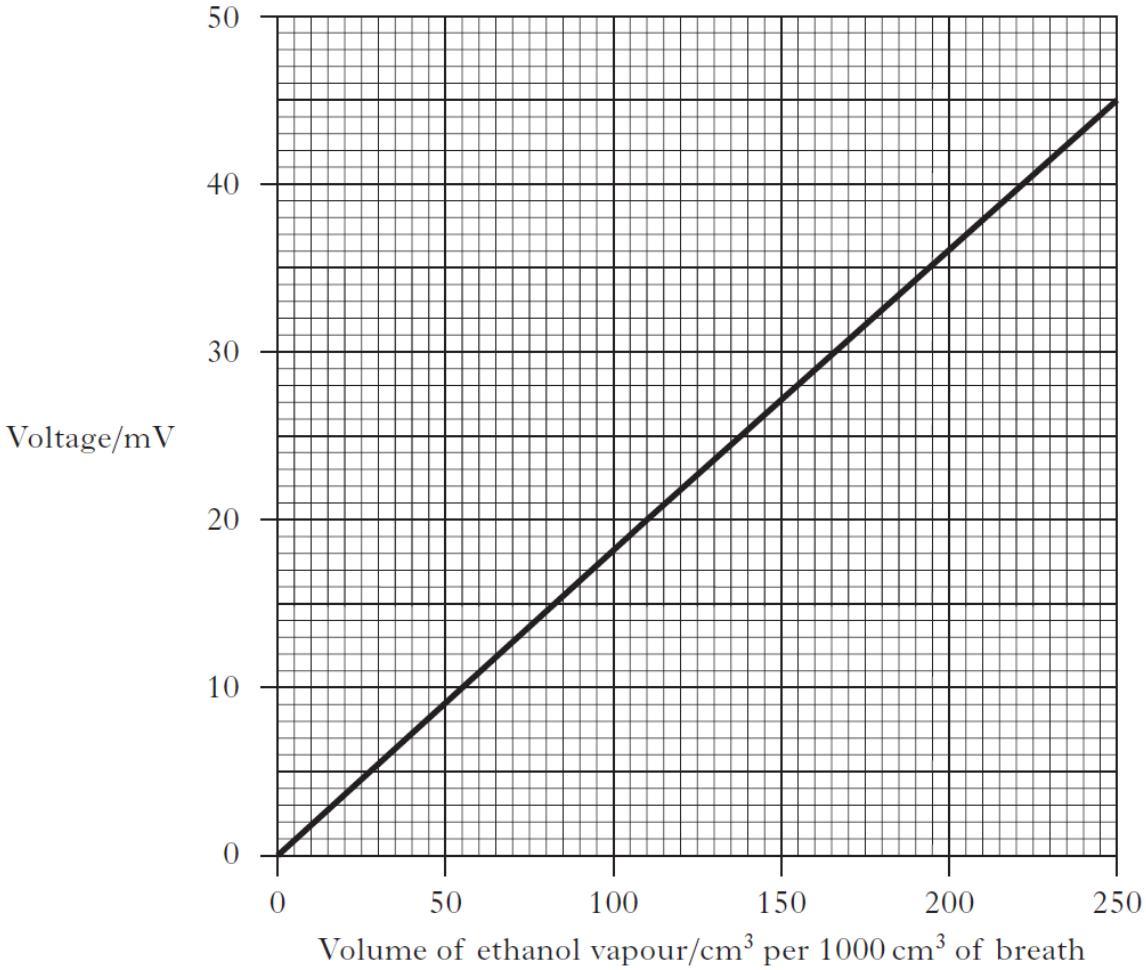
Calculate the volume, in litres, of gas released when 1·0 g of RDX decomposes.

Take the molar volume of the gases to be 24 litres mol^{-1}.

3

[12a.R2014]

8. Different ethanol vapour concentrations produce different voltages as is shown in the graph below.



Calculate the mass of ethanol, in g, in 1000 cm^3 of breath when a voltage of 20 mV was recorded.

(Take the molar volume of ethanol, C_2H_5OH, vapour to be 24 litres mol^{-1}.)

Show your working clearly.

3

[Q5a.R2012]

9. An experiment was carried out to measure the concentration of hypochlorite ions in a sample of bleach. In this experiment, the bleach sample reacted with excess hydrogen peroxide.

$$H_2O_2(aq) + ClO^-(aq) \rightarrow H_2O(\ell) + Cl^-(aq) + O_2(g)$$

By measuring the volume of oxygen given off, the concentration of bleach can be calculated.

80 cm^3 of oxygen gas was produced from 5·0 cm^3 of bleach.

Calculate the concentration of the hypochlorite ions in the bleach.

(Take the molecular volume of oxygen to be 24 litre mol^{-1}.)

4

[Q7d.R2011]

10. Hydrogen sulfide is a toxic gas with the smell of rotten eggs.

Hydrogen sulfide gas can be prepared by the reaction of iron(II) sulfide with excess dilute hydrochloric acid:

$$FeS(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2S(g)$$

Calculate the mass, in g, of iron(II) sulfide required to produce 79 cm^3 of hydrogen sulfide gas.

(Take the molar volume of hydrogen sulfide to be 24 litres mol^{-1}.)

Show your working clearly.

3

[Q7d(ii).R2013]

4) Oxidising and Reducing Agents & Chemical Analysis

1. In which reaction is hydrogen gas acting as an oxidising agent?

A $H_2 + CuO \rightarrow H_2O + Cu$

B $H_2 + C_2H_4 \rightarrow C_2H_6$

C $H_2 + Cl_2 \rightarrow 2HCl$

D $H_2 + 2Na \rightarrow 2NaH$

[Q39.2010]

2. During a redox process in acid solution, iodate ions are converted into iodine.

$$2IO_3^-(aq) + 12H^+(aq) + \mathbf{x}e^- \rightarrow I_2(aq) + 6H_2O(\ell)$$

To balance the equation, what is the value of x?

A 2

B 6

C 10

D 12. [Q37.2011]

3. The following reactions take place when nitric acid is added to zinc.

$$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(\ell)$$

$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$$

How many moles of NO_3^- (aq) are reduced by one mole of zinc?

A 2/3

B 1

C 3/2

D 2. [Q38.2011]

4. Four metals W, X, Y and Z and their compounds behaved as described.

(i) Only X, Y and Z reacted with dilute hydrochloric acid.

(ii) The oxides of W, X and Y were reduced to the metal when heated with carbon powder. The oxide of Z did not react.

(iii) A displacement reaction occurred when X was added to an aqueous solution of the nitrate of Y.

What is the correct order of reactivity of these metals (most reactive first)?

A W, Y, X, Z

B W, X, Y, Z

C Z, X, Y, W

D Z, Y, X, W. [Q37.2011]

5. A student obtained a certain volume of carbon dioxide by the reaction of 20 cm^3 of 2 mol l^{-1} hydrochloric acid with excess sodium carbonate.

$$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + CO_2(g)$$

Which solution of sulfuric acid would give the same final volume of carbon dioxide when added to excess sodium carbonate?

$$H_2SO_4(aq) + Na_2CO_3(aq) \rightarrow Na_2SO_4(aq) + CO_2(g)$$

A 10 cm^3 of 2 mol l^{-1} sulfuric acid

B 20 cm^3 of 2 mol l^{-1} sulfuric acid

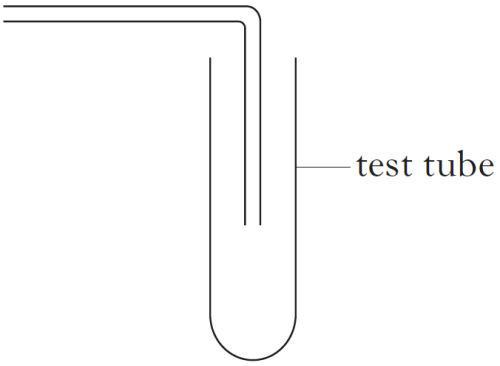
C 10 cm^3 of 4 mol l^{-1} sulfuric acid

D 20 cm^3 of 4 mol l^{-1} sulfuric acid. [Q22.R2011]

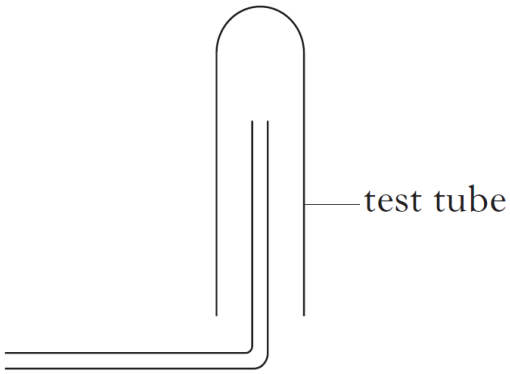
6. Sulphur dioxide gas is more dense than air and is very soluble in water.

Which of the following diagrams shows the most appropriate apparatus for collecting and measuring the volume of sulphur dioxide given off in a reaction?

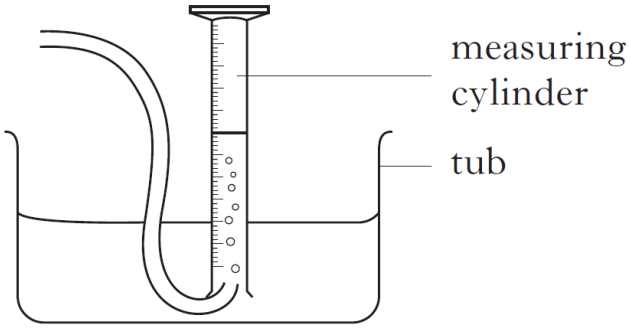
A



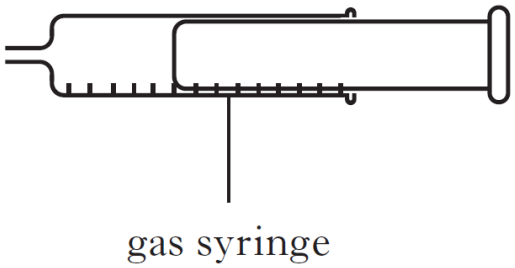
B



C



D



[Q30. R2011]

7. The correct method of filling a 20 cm^3 pipette is to draw the liquid into the pipette

A doing it slowly at the end, until the top of the meniscus touches the mark

B doing it slowly at the end, until the bottom of the meniscus touches the mark

C to above the mark and then release liquid from the pipette until the top of the meniscus touches the mark

D to above the mark and then release liquid from the pipette until the bottom of the meniscus touches the mark.

[Q29.R2014]

8. A 0·10 mol l^{-1} solution could be prepared most accurately from a 1·0 mol l^{-1} solution using

A a 1 cm^3 dropping pipette and a 10 cm^3 measuring cylinder

B a 10 cm^3 measuring cylinder and a 100 cm^3 volumetric flask

C a 25 cm^3 pipette and a 250 cm^3 volumetric flask

D a 50 cm^3 burette and a 500 cm^3 measuring cylinder.. [Q30.R2014]

9. 45 cm^3 of a solution could be most accurately measured out using a

A 50 cm^3 beaker

B 50 cm^3 burette

C 50 cm^3 pipette

D 50 cm^3 measuring cylinder. [Q29.R2013]

10. The alcohol content of wine was analysed by four students. Each student carried out the experiment three times.

	Experiment 1 (%)	Experiment 2 (%)	Experiment 3 (%)
Student A	10·0	9·0	8·0
Student B	6·4	6·6	6·8
Student C	6·5	6·6	6·6
Student D	9·0	8·5	9·6

The most reproducible results were obtained by

A Student A

B Student B

C Student C

D Student D. [Q30.R2012]

11. Aluminium carbonate can be produced by the following reaction.

$$2AlCl_3(aq) + 3K_2CO_3(aq) \rightarrow Al_2(CO_3)_3(s) + 6KCl(aq)$$

The most suitable method for obtaining a sample of the aluminium carbonate is

A collection over water

B distillation

C evaporation

D filtration. [Q22.R2011]

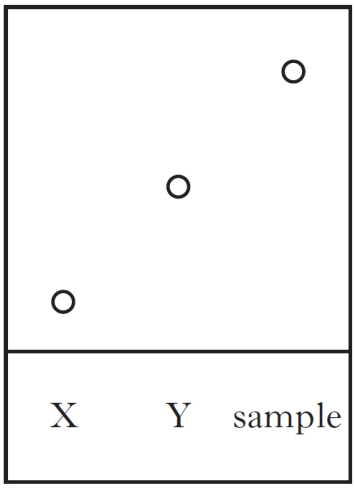
12. An organic chemist is attempting to synthesise a fragrance compound by the following chemical reaction.

$$\text{compound } \mathbf{X} + \text{compound } \mathbf{Y} \rightarrow \text{fragrance compound}$$

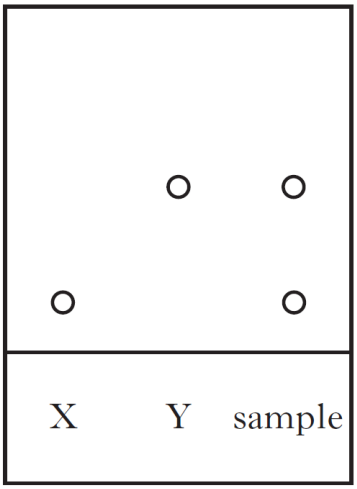
After one hour, a sample is removed and compared with pure samples of compounds X and Y using thin-layer chromatography.

Which of the following chromatograms shows that the reaction has produced a pure sample of the fragrance compound?

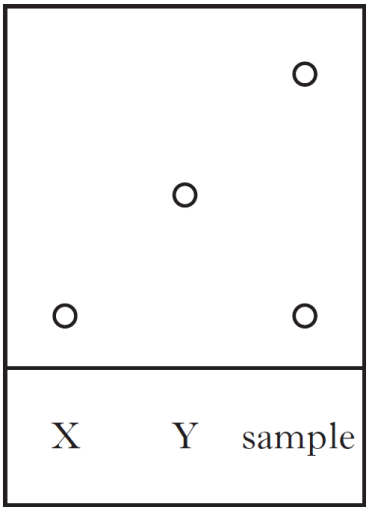
A



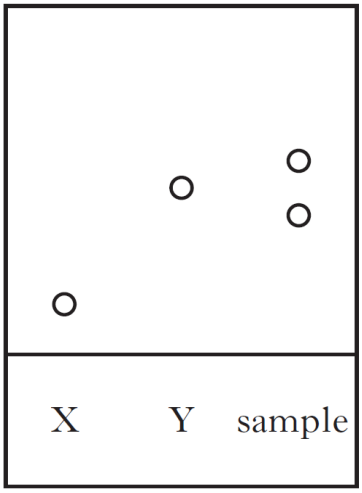
B



C



D



[Q29. R2012]

13. Solutions containing iodine are used to treat foot rot in sheep.

The concentration of iodine in a solution can be determined by titrating with a solution of thiosulfate ions.

$$I_2 + \underbrace{2S_2O_3^{2-}}_{\text{thiosulfate ions}} \rightarrow 2I^- + S_4O_6^{2-}$$

(a) Write an ion-electron equation for the reaction of the oxidising agent in the titration.

1

(b) Three 20·0 cm^3 samples of a sheep treatment solution were titrated with 0·10 mol l^{-1} thiosulfate solution.

The results are shown below.

Sample	Volume of thiosulfate/cm^3
1	18·60
2	18·10
3	18·20

(i) Why is the volume of sodium thiosulfate used in the calculation taken to be 18·15 cm^3, although this is not the average of the three titres in the table?

1

(ii) Calculate the concentration of iodine, in mol l^{-1}, in the foot rot treatment solution.

Show your working clearly.

3

(iii) Describe how to prepare 250 cm^3 of a 0·10 mol l^{-1} standard solution of sodium thiosulfate, $Na_2S_2O_3$.

Your answer should include the mass, in g, of sodium thiosulfate required.

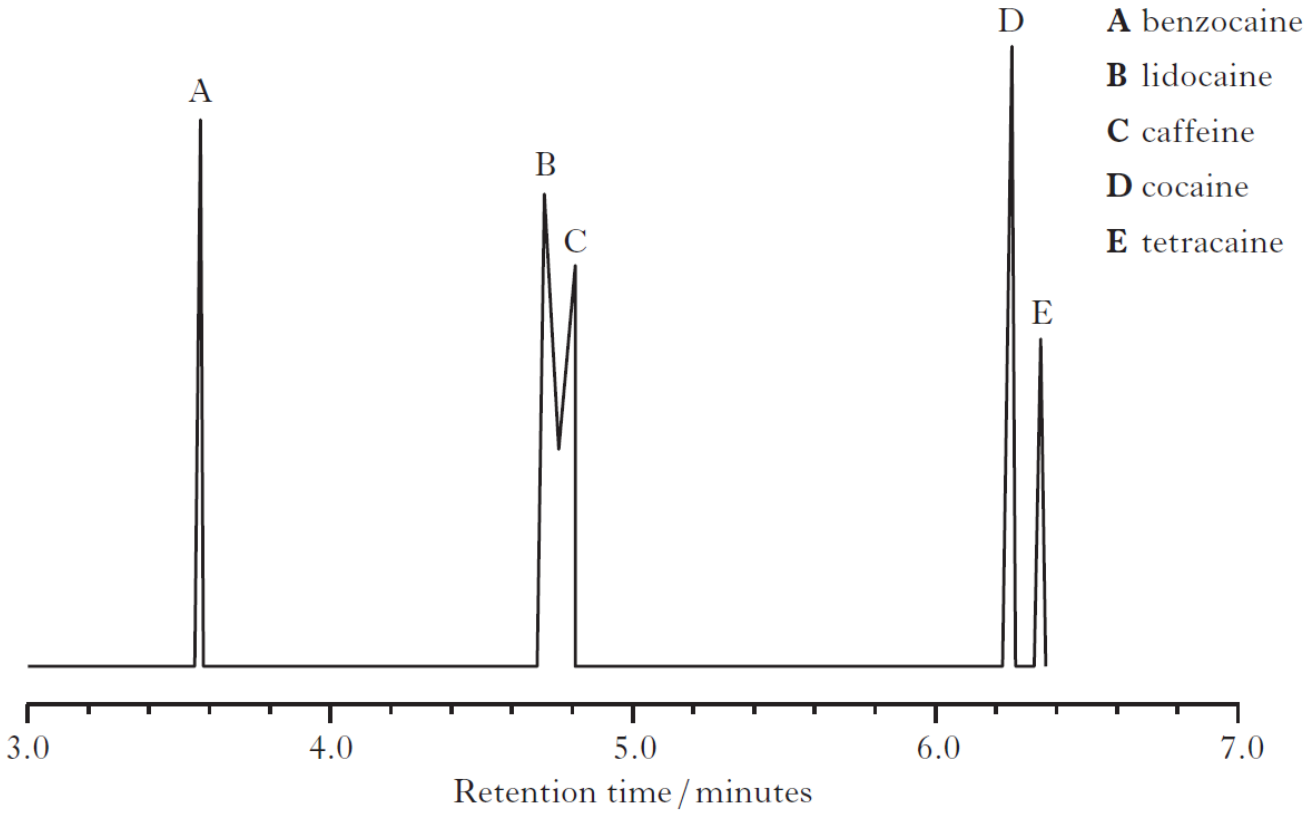
3

(8)

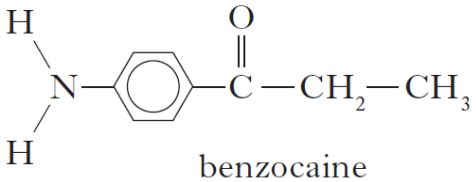
[Q10.R2013]

14. When forensic scientists analyse illegal drugs, anaesthetics such as lidocaine are sometimes found to be present.

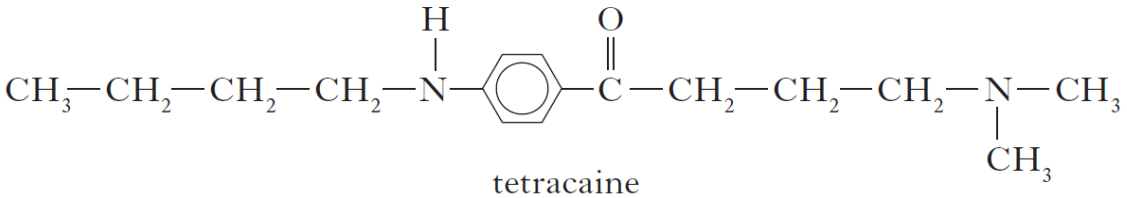
The gas chromatogram below is from an illegal drug.



(a) The structures of benzocaine and tetracaine are shown below.



benzocaine



tetracaine

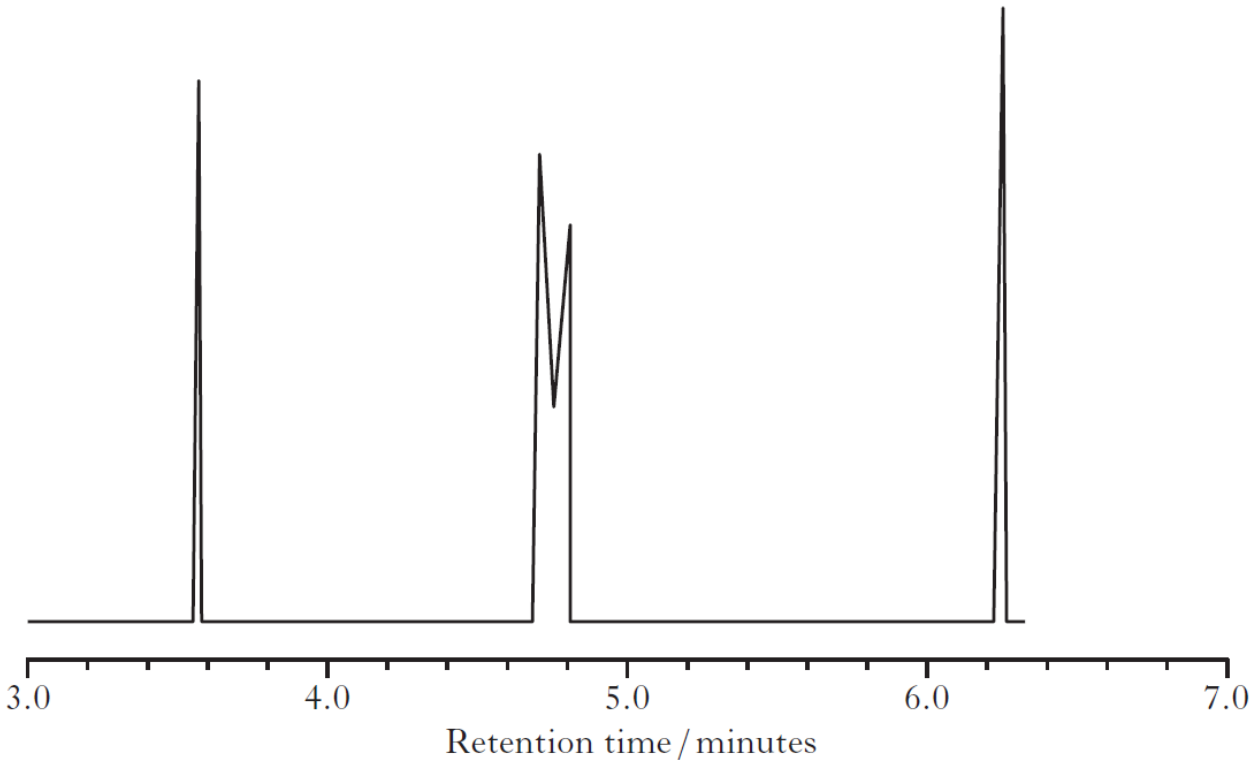
Suggest why benzocaine has a shorter retention time than tetracaine.

1

(b) Why is it difficult to obtain accurate values for the amount of lidocaine present in a sample containing large amounts of caffeine?

1

(c) Add a peak to the diagram below to complete the chromatogram for a second sample that only contains half the amount of tetracaine compared to the first.



1

(3)

[Q6d.R2013]

15. When $ClO^-(aq)$ acts as a bleach, it is reduced to produce the $Cl^-(aq)$ ion.

$$ClO^-(aq) \rightarrow Cl^-(aq)$$

Complete the above to form the ion-electron equation for the reduction reaction.

1

[Q7c.R2011]

16. A student carried out an investigation to measure the nitrite level in the school water supply.

A compound, which reacts with the nitrite ions to form a product that absorbs light, is added to water samples. The higher the concentration of nitrite ions present in a water sample, the greater the amount of light absorbed.

(a) The student prepared potassium nitrite solutions of known concentration by diluting samples from a stock solution.

(i) Calculate the mass, in mg, of potassium nitrite, KNO_2, needed to make 1 litre of stock solution with a nitrite ion concentration of 250 mg l^{-1}.

2

(ii) Describe how the weighed potassium nitrate is dissolved to prepare the stock solution to ensure that its concentration is accurately known.

2

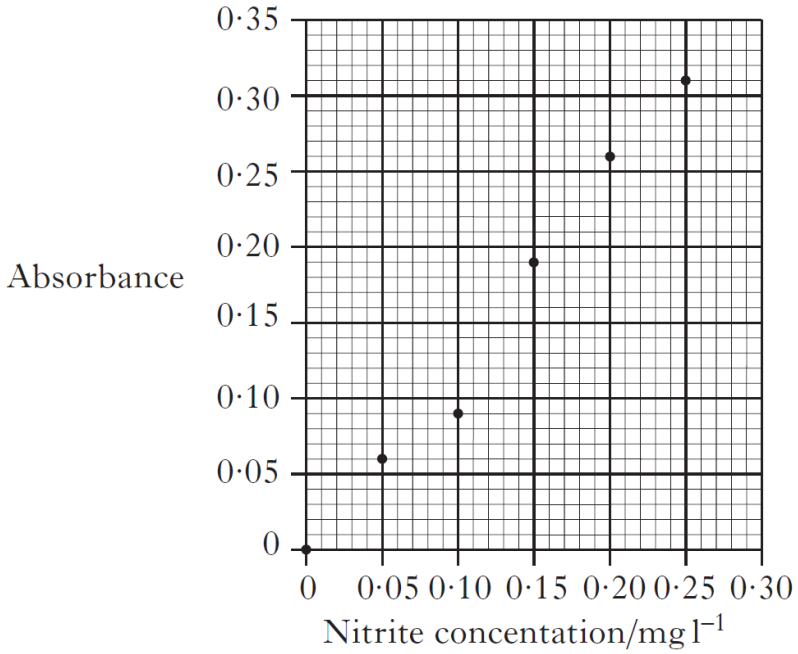
(iii) Why should the student use distilled or deionised water rather than tap water when dissolving the potassium nitrite?

1

(iv) To prepare a solution with a nitrite ion concentration of 0·05 g l^{-1} the student dilutes the stock solution. Why is this method more accurate than preparing a solution by weighing out potassium nitrite?

1

(b) The graph below shows results for five solutions of potassium nitrite and a sample of distilled water.



The results for four tap water samples are shown below.

	Absorbance
Sample One	0·09
Sample Two	0·09
Sample Three	0·33
Sample Four	0·09

What is the concentration of nitrite ions, in mg l^{-1}, in the tap water?

1
(7)
[Q9.R2011]

17. Dark blue compounds can be made by reacting ammonia with copper ions.

To determine the number of ammonia molecules that react with each copper ion, a student prepared the following mixtures and measured their colour intensity.

Mixture	A	B	C	D	E	F
Volume of 0·1 mol l^{-1} Cu^{2+} solution, cm^3	7·5	5·0	2·5	2·0	1·5	1·0
Volume of 0·1 mol l^{-1} NH_3 solution, cm^3	2·5	5·0	7·5	8·0	8·5	
Colour intensity	0·61	1·23	1·83	1·96	1·47	0·98

(a) Complete the table to show the volume of NH_3 solution required for the final experiment.

1

(b) The number of ammonia molecules that react with each copper ion can be found from the mixture with the greatest colour intensity.

How many ammonia molecules react with each copper ion?

1

(2)

[Q9.R2013]

18. The chlorine used in the experiment is made in a redox reaction between permanganate ions and chloride ions.

The ion-electron equations for the oxidation and reduction reactions are

$$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$$

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(\ell)$$

Write a balanced equation for the reaction of permanganate ions with chloride ions to produce chlorine gas.

(1)

[Q2c.R2011]

5) Equilibria

1. In a reversible reaction, equilibrium is reached when

A molecules of reactants cease to change into molecules of products

B the concentrations of reactants and products are equal

C the concentrations of reactants and products are constant

D the activation energy of the forward reaction is equal to that of the reverse reaction.

[Q22.R2011]

2. A few drops of concentrated sulphuric acid were added to a mixture of 0·1 mol of methanol and 0·2 mol of ethanoic acid. Even after a considerable time, the reaction mixture was found to contain some of each reactant.

Which of the following is the best explanation for the incomplete reaction?

A The temperature was too low.

B An equilibrium mixture was formed.

C Insufficient methanol was used.

D Insufficient ethanoic acid was used. [Q21.R2012]

3.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The equation represents a mixture at equilibrium.

Which line in the table is true for the mixture after a further 2 hours of reaction?

	Rate of forward reaction	Rate of back reaction
A	decreases	decreases
B	increases	increases
C	unchanged	decreases
D	unchanged	unchanged

[Q22.R2013]

4. Which line in the table describes dynamic equilibrium?

	Concentration of reactants and products	Forward and reverse reaction rates
A	constant	equal
B	constant	not equal
C	not constant	equal
D	not constant	not equal

[Q20.R2014]

5. In which of the following would an increase in pressure result in the equilibrium position being moved to the left?

A $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

B $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

C $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

D $Fe_2O_3(s) + 3CO(g) \rightleftharpoons 2Fe(s) + 3CO_2(g)$

[Q23.R2013]

6. Ethanol is manufactured by reacting ethene with steam.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

$$\Delta H = -46\,kJ\,mol^{-1}$$

Which set of conditions would give the best yield of ethanol at equilibrium?

A High temperature, low pressure

B High temperature, high pressure

C Low temperature, high pressure

D Low temperature, low pressure. [Q23.R2011]

7. Ammonia is made by the Haber Process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The equilibrium position lies to the left.

Which line in the table is correct?

	Atom Economy	Percentage Yield
A	high	high
B	high	low
C	low	high
D	low	low

[Q24.R2013]

8. The following reaction takes place in a blast furnace:

$$CO_2(g) + C(s) \rightleftharpoons 2CO(g) \quad \Delta H = +174\,kJ\ mol^{-1}$$

Which conditions of pressure and temperature would favour the production of carbon monoxide?

A Low pressure and low temperature

B High pressure and low temperature

C Low pressure and high temperature

D High pressure and high temperature. [Q21.R2014]

9. In many bathroom cleaning products, the bleaching agent is the hypochlorite ion, $ClO^-(aq)$.

(a) Hypochlorite bleaches can be made by reacting sodium hydroxide with chlorine. Sodium hypochlorite, sodium chloride and water are formed.

Write a balanced equation for the reaction.

2

(b) In the bleach solution, the following equilibrium exists.

$$Cl_2(aq) + H_2O(\ell) \rightleftharpoons 2H^+(aq) + ClO^-(aq) + Cl^-(aq)$$

Explain why the addition of sodium hydroxide increases the bleaching efficiency of the solution.

2

[Q7ab.R2011]

10. Carbon monoxide and hydrogen react to produce methanol.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -91\ kJ\ mol^{-1}$$

Circle the correct words in the table to show the changes to temperature and pressure that would favour the production of methanol.

temperature	decrease / keep the same / increase
pressure	decrease / keep the same / increase

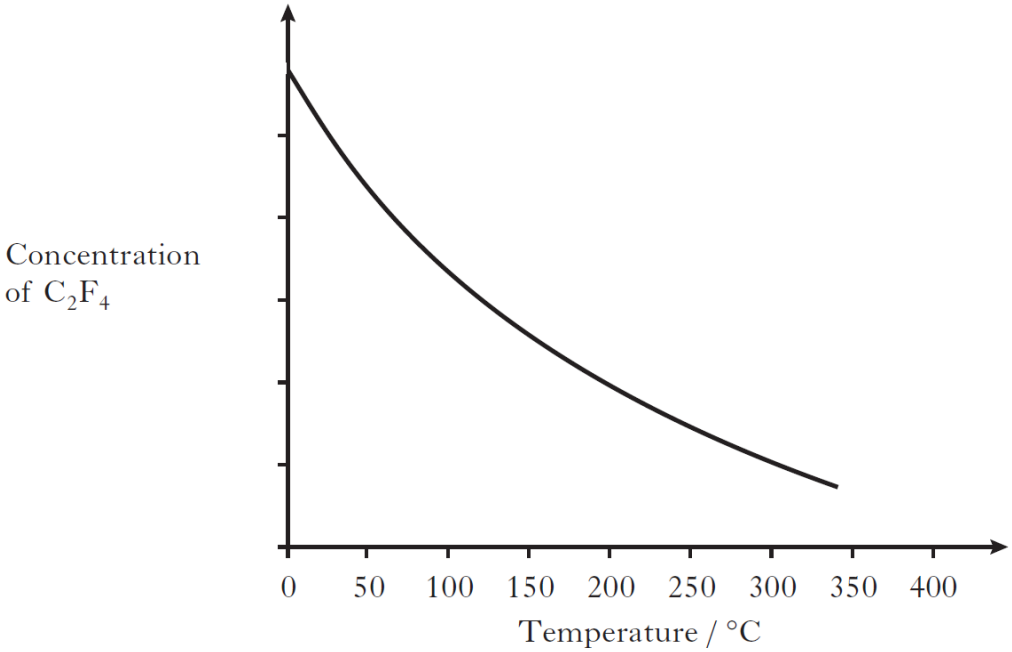
1

[Q8b.R2013]

11. Tetrafluoroethene, C_2F_4, is produced in industry by a series of reactions.
The final reaction in its manufacture is shown below.

$$2CHClF_2(g) \rightleftharpoons C_2F_4(g) + 2HCl(g)$$

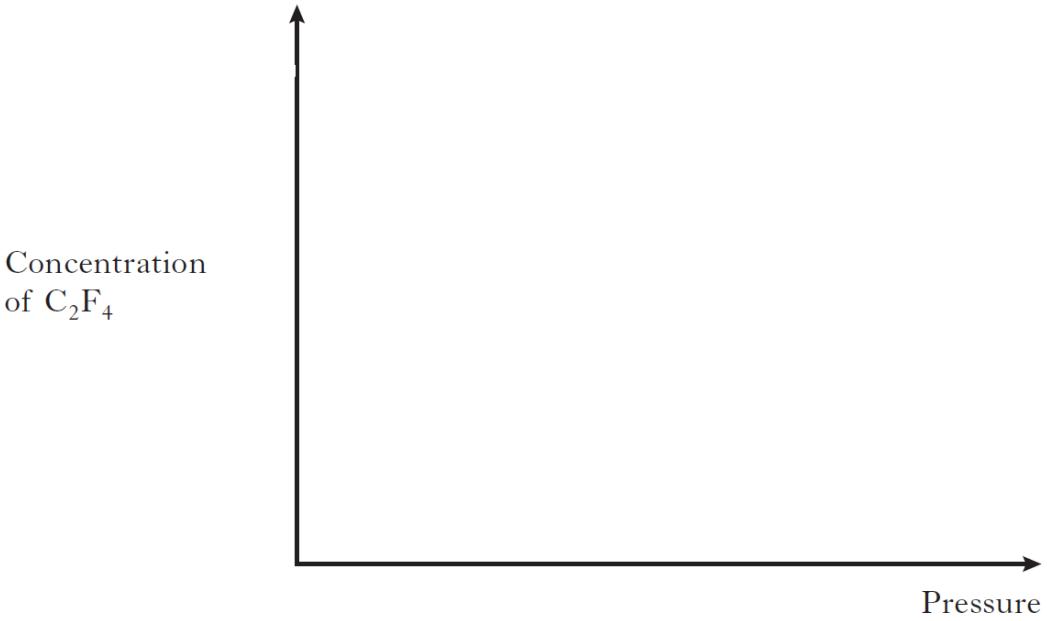
The graph shows the variation in concentration of C_2F_4 formed as temperature is increased.



(a) What conclusion can be drawn about the enthalpy change for the formation of tetrafluoroethene?

1

(b) Sketch a graph to show how the concentration of tetrafluoroethene formed would vary with increasing pressure.



1

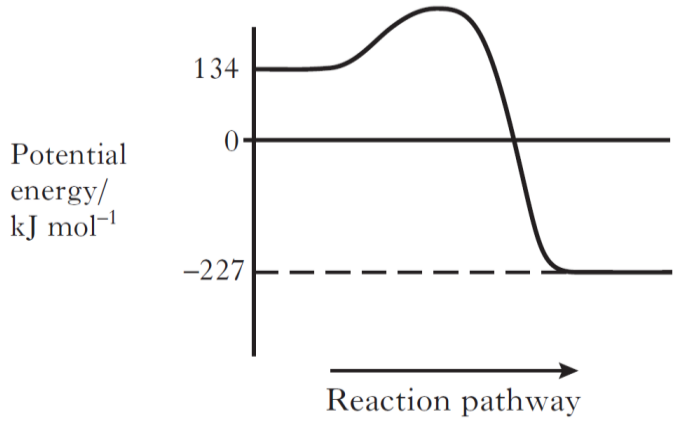
[Q13c.R2012]

6) Chemical Energy

1. The potential energy diagram for the reaction

$$CO(g) + NO_2(g) \rightarrow CO_2(g) + NO(g)$$

is shown.



ΔH, in kJ mol^{-1}, for the forward reaction is

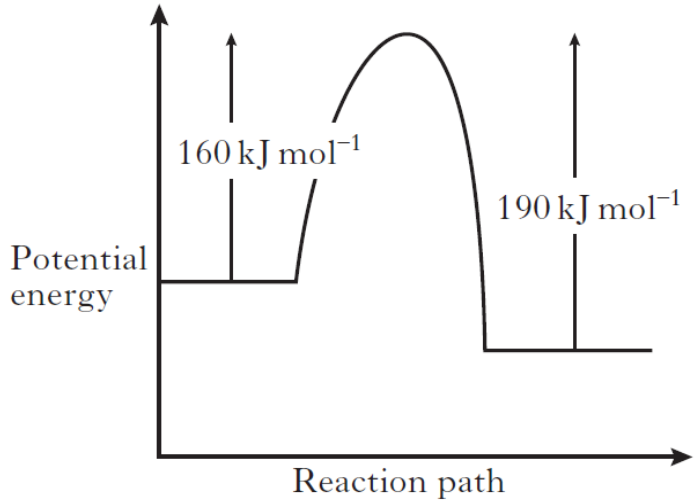
A +361

B -93

C -227

D -361. [Q25.R2011]

2.



When a catalyst is used, the activation energy of the forward reaction is reduced to 35 kJ mol^{-1}. What is the activation energy of the catalysed reverse reaction?

A 30 kJ mol^{-1}

B 35 kJ mol^{-1}

C 65 kJ mol^{-1}

D 190 kJ mol^{-1} [Q24.R2014]

3. Which of the following is **not** a correct statement about the effect of a catalyst?

The catalyst

A provides energy so that more molecules have successful collisions

B lowers the energy which molecules need for successful collisions

C provides an alternative route to the products

D forms bonds with reacting molecules. [Q26.R2011]

4. Which line in the table applies correctly to the use of a catalyst in a chemical reaction?

	Position of equilibrium	Effect on value of ΔH
A	Moved to right	Decreased
B	Unaffected	Increased
C	Moved to left	Unaffected
D	Unaffected	Unaffected

[Q22.R2012]

5. The enthalpy of combustion of an alcohol is always the enthalpy change for

A the alcohol burning in 1 mole of oxygen

B the alcohol burning to produce 1 mole of water

C 1 mole of the alcohol burning completely in oxygen

D 1 mole of the alcohol burning to produce 1 mole of carbon dioxide.

[Q26.R2014]

6. Excess iron was added to 100 cm^3 of 1·0 mol l^{-1} copper(II) sulfate solution releasing 3·1 kJ of energy.

$$Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_4(aq)$$

What is the enthalpy change, in kJ mol^{-1} for the above reaction?

A −0·31

B −3·1

C −31

D −310. [Q25.R2014]

7. The enthalpy of combustion of methanol is -727 kJ mol^{-1}.
What mass of methanol has to be burned to produce 72·7 kJ?

A 3·2 g

B 32·0 g

C 72·7 g

D 727·0 g. [Q27.R2013]

8. Aluminium reacts with oxygen to form aluminium oxide.

$$2Al(s) + 1½O_2(g) \rightarrow Al_2O_3(s) \quad \Delta H = -1670\,kJ\ mol^{-1}$$

What is the enthalpy of combustion of aluminium in kJ mol^{-1}?

A −835

B −1113

C −1670

D +1670. [Q27.R2012]

9. $5N_2O_4(\ell) + 4CH_3NHNH_2(\ell) \rightarrow 4CO_2(g) + 12H_2O(\ell) + 9N_2(g) \quad \Delta H = -5116\,kJ$

The energy released when 2 moles of each reactant are mixed and ignited is

A 2046 kJ

B 2558 kJ

C 4093 kJ

D 5116 kJ. [Q21.R2013]

10. In the presence of bright light, hydrogen and chlorine react explosively. One step in the reaction is shown below.

$$H_2(g) + Cl(g) \rightarrow HCl(g) + H(g)$$

The enthalpy change for this step can be represented as

A (H-H bond enthalpy) + (Cl-Cl bond enthalpy)

B (H-H bond enthalpy) − (Cl-Cl bond enthalpy)

C (H-H bond enthalpy) + (H-Cl bond enthalpy)

D (H-H bond enthalpy) − (H-Cl bond enthalpy). [Q28.R2012]

11. The mean bond enthalpy of the N−H bond is equal to one third of the value of ΔH for which change?

A $N(g) + 3H(g) \rightarrow NH_3(g)$

B $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

C $\frac{1}{2}N_2(g) + 1\frac{1}{2}H_2(g) \rightarrow NH_3(g)$

D $NH_3(g) \rightarrow \frac{1}{2}N_2(g) + 1\frac{1}{2}H_2(g)$

[Q29.R2011]

12.

$$C(s) + H_2(g) + O_2(g) \rightarrow HCOOH(\ell) \qquad \Delta H = a$$

$$HCOOH(\ell) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g) + H_2O(\ell) \qquad \Delta H = b$$

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = c$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) \qquad \Delta H = d$$

What is the relationship between a, b, c and d?

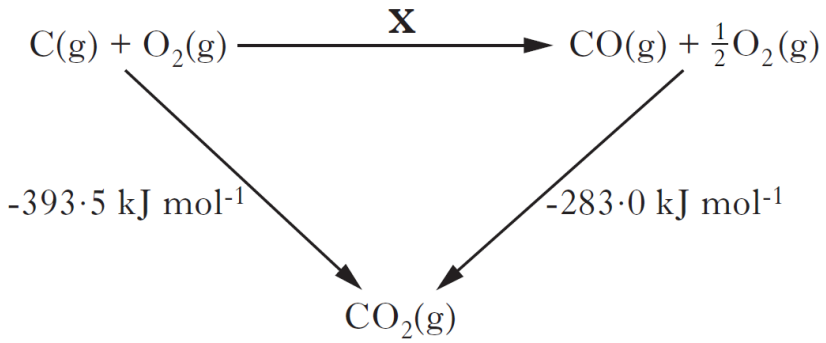
A a = c + d − b

B a = b − c − d

C a = −b − c − d

D a = c + b + d. [Q28.R2013]

13. Consider the reaction pathways shown below.



According to Hess's law, the enthalpy change for reaction X is

A -676·5 kJ mol^{-1}

B -110·5 kJ mol^{-1}

C +110·5 kJ mol^{-1}

D +676·5 kJ mol^{-1}. [Q28.R2011]

14.

$$C(\text{graphite}) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -394\,\text{kJ mol}^{-1}$$

$$C(\text{diamond}) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -395\,\text{kJ mol}^{-1}$$

What is the enthalpy change, in kJ mol^{-1}, for the conversion of one mole of graphite into one mole of diamond?

A +789

B +1

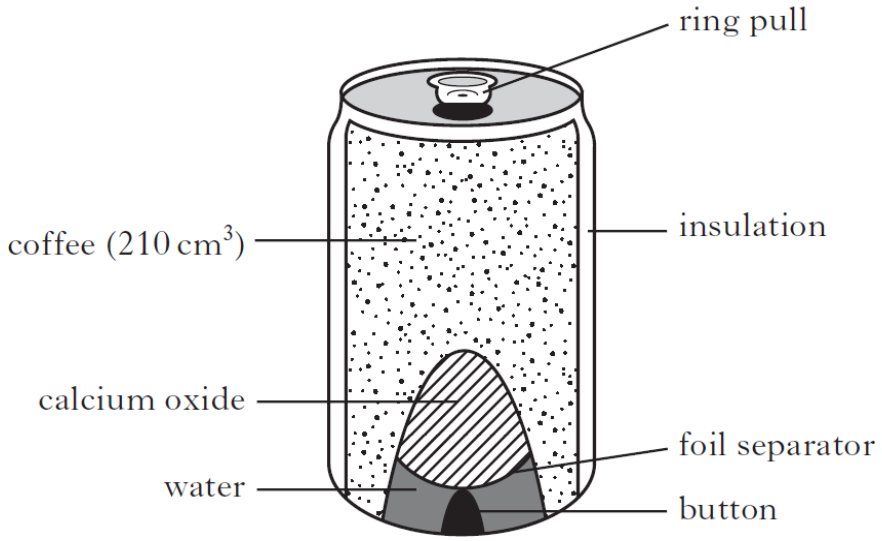
C −1

D −789. [Q27.R2014]

15. Self-heating cans may be used to warm drinks such as coffee.

When the button on the can is pushed, a seal is broken, allowing water and calcium oxide to mix and react.

The reaction produces solid calcium hydroxide and releases heat.



The equation for this reaction is:

$$CaO(s) + H_2O(\ell) \rightarrow Ca(OH)_2(s) \qquad \Delta H = -65\ kJ\ mol^{-1}$$

(a) Calculate the mass, in grams, of calcium oxide required to raise the temperature of 210 cm^3 of coffee from 20^{o}C to 70^{o}C.

Show your working clearly.

3

(b) If more water is used the calcium hydroxide is produced as a solution instead of as a solid.
The equation for the reaction is:

$$CaO(s) + H_2O(\ell) \rightarrow Ca(OH)_2(aq)$$

Using the following data, calculate the enthalpy change, in kJ mol^{-1}, for this reaction.

$$Ca(s) + \tfrac{1}{2}O_2(g) \rightarrow CaO(s) \qquad \Delta H = -635\ kJ\ mol^{-1}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) \qquad \Delta H = -286\ kJ\ mol^{-1}$$

$$Ca(s) + O_2(g) + H_2(g) \rightarrow Ca(OH)_2(s) \qquad \Delta H = -986\ kJ\ mol^{-1}$$

$$Ca(OH)_2(s) \rightarrow Ca(OH)_2(aq) \qquad \Delta H = -82\ kJ\ mol^{-1}$$

Show your working clearly.

2
[Q4b.R2014]

16. Methane can be reacted with steam to produce a mixture of carbon monoxide and hydrogen.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

Use the data below to calculate the enthalpy change, in kJ mol^{-1}, for the forward reaction.

$$CO(g) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -283\ kJ\ mol^{-1}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(g) \qquad \Delta H = -242\ kJ\ mol^{-1}$$

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \qquad \Delta H = -803\ kJ\ mol^{-1}$$

Show your working clearly.

2
[Q8a.R2013]

17. The production of hydrogen chloride from hydrogen and chlorine is exothermic.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

Using bond enthalpy values, calculate the enthalpy change, in kJ mol^{-1}, for this reaction.

2

[2c(iii).R2011]

18. 2-Methylpropan-1-ol may be used as an alternative to ethanol as a fuel.

Ethanol releases 29·7 kJ of energy for every gram of fuel burned.

Using the information from the table below, show by calculation that 2-methylpropan-1-ol releases more energy than the same mass of ethanol when burnt.

	2-methylpropan-1-ol
Mass of one mole/g	74
Enthalpy of combustion/kJ mol^{-1}	–2669

1

[Q10b(ii).R2011]

19. The energy density value of a fuel is the energy released when one kilogram of the fuel is burned.

The enthalpy of combustion of ethanol is −1367 kJ mol^{-1}.

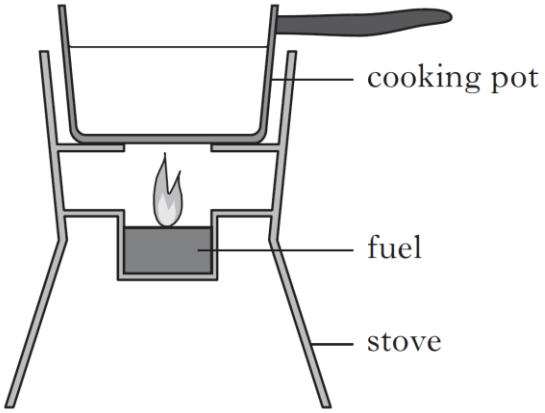
Calculate the energy density value, in kJ kg^{-1}, of ethanol.

1

[Q2b.R2014]

20. Different fuels are used for different purposes.

Ethanol, C_2H_5OH, can be used as a fuel in some camping stoves.



(a) The enthalpy of combustion of ethanol given in the data booklet is −1367 kJ mol^{-1}.

Using this value, calculate the mass of ethanol, in g, required to raise the temperature of 500 g of water from 18°C to 100°C.

Show your working clearly.

3

(b) Suggest **two** reasons why less energy is obtained from burning ethanol in the camping stove than is predicted from its enthalpy of combustion.

2

[Q3a.R2012]