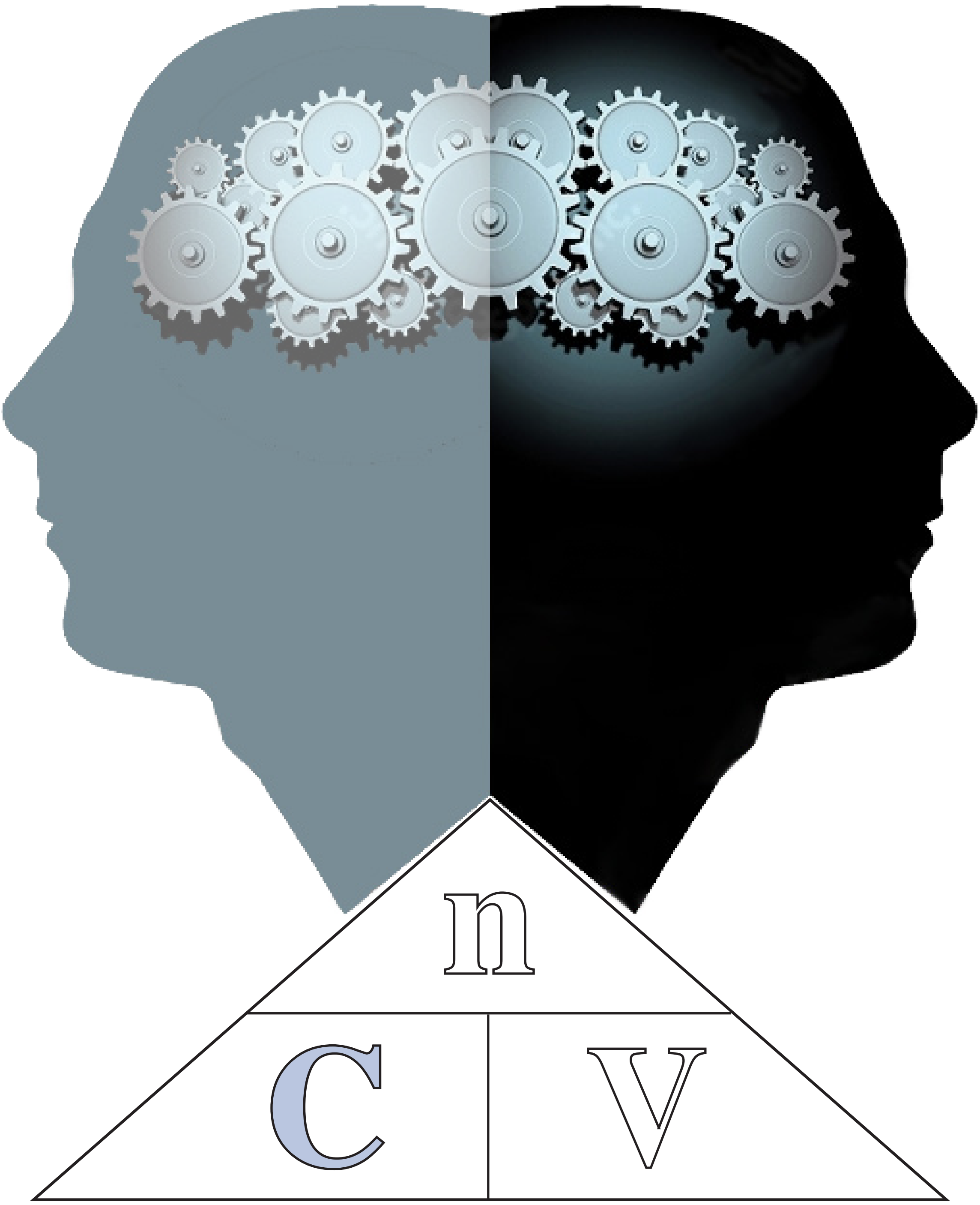
CHEMISTRY CALCULATIONS



2. Exam Practice

These sheets belong to ______________________________

Introduction

This is the second of two booklets I've written to help teach the calculations for National 5 Chemistry as taught in Scotland. The first booklet described the methods for these calculations and gave a few 'Self-Check' problems.

This 2nd booklet will be questions extracted from previous exam papers (N5, Standard Grade & Intermediate 2) to show the questions in context.

*CfE (new courses) calculations are now marked in a different way with extra emphasis placed on the "Concept" (**correct formula** chosen and **values** inserted). Only if the Concept is correct will marks be awarded for correct Arithmetic.*

Though full marks may be awarded for correct answer (with no working shown) on assumption that pupil must have used correct concepts, it would be better to show working in order to avoid getting zero marks.

*Units are important (%, g, moles, mol l^{-1}) but to avoid drastic penalisation **most** (but not all) questions will include the required units in question. Therefore you do not always need to give the units but you will be penalised if you give wrong units.*

Formulae given in the Data Booklet

1. Formula Mass
2. Percentage Composition $\quad \% \; by \; mass = \frac{m}{GFM} \times 100$
3. Molar Mass (gfm)
4. Molar Calculations $\quad n = \frac{m}{GFM}$
5. Using Balanced Equations
6. Concentration of Solutions $\quad n = CV$
7. Titrations $\quad \frac{C_1V_1}{n_1} = \frac{C_2V_2}{n_2}$

Q1 Urea, H_2NCONH_2, can be used as a fertiliser.

(a) Calculate the percentage of nitrogen in urea. **3**
Show your working clearly.

Q2 Ores are naturally occurring compounds from which metals can be extracted.

(b) Iron can be extracted from its ore haematite, Fe_2O_3, in a blast furnace.

Calculate the percentage by mass of iron in haematite. **3**

Show your working clearly.

Q3 Metals can be extracted from their ores by different methods.

(*a*) Place the following methods in the correct space in the table.

You may wish to use the data booklet to help you.

reacting with carbon
electrolysis
heat alone

Metal	Method
mercury	
iron	
magnesium	

1

(*b*) Mercury can be extracted from the ore cinnabar, **HgS**.

(i) Calculate the percentage by mass of mercury in cinnabar. **2**

Q4 Potassium hydroxide reacts with sulphuric acid to form potassium sulphate, which can be used as a fertiliser.

$$KOH(aq) \quad + \quad H_2SO_4(aq) \longrightarrow K_2SO_4(aq) \quad + \quad H_2O(\ell)$$

(*a*) Balance the above equation. **1**

(*b*) Name the type of chemical reaction taking place.

____ **1**

(*c*) Calculate the percentage, by mass, of potassium in potassium sulphate, K_2SO_4.

Show your working clearly. **2**

Q5 Read the passage below and answer the questions that follow.

Potassium – The Super Element

Potassium is an essential element for almost all living things. The human body requires a regular intake of potassium because humans have no mechanism for storing it. Foods rich in potassium include raisins and almonds. Raisins contain 0·86 g of potassium in every 100 g.

Naturally occurring salts of potassium such as saltpetre (potassium nitrate) and potash (potassium carbonate) have been known for centuries. Potassium salts are used as fertilisers.

Potassium was first isolated by Humphry Davy in 1807. Davy observed that when potassium was added to water it formed globules which skimmed about on the surface, burning with a coloured flame and forming an alkaline solution.

(a) State why the human body requires a regular intake of potassium. **1**

(b) Calculate the number of moles of potassium in 100 g of raisins. **2**

Show your working clearly.

Q6 Dishwasher tablets contain many different types of chemicals.

(*a*) A dishwasher tablet was found to contain 1·57 g of the bleaching agent, sodium percarbonate.

How many moles are there in 1·57g of sodium percarbonate?

(Formula mass of sodium percarbonate = 157.) **1**

Q7 Rhubarb contains oxalic acid, $C_2H_2O_4$.

(*c*) A strip of rhubarb was found to contain 1·8 g of oxalic acid.

How many moles of oxalic acid, $C_2H_2O_4$, are contained in 1·8 g.

(Formula mass of oxalic acid = 90) **1**

Q8 The concentration of chloride ions in water affects the ability of some plants to grow.

A student investigated the concentration of chloride ions in the water at various points along the river Tay.

The concentration of chloride ions in water can be determined by reacting the chloride ions with silver ions.

$$Ag^{+}(aq) \quad + \quad Cl^{-}(aq) \quad \rightarrow \quad AgCl(s)$$

A 20 cm^3 water sample gave a precipitate of silver chloride with a mass of 1·435 g.

(a) Calculate the number of moles of silver chloride, AgCl, present in this sample. **2**

Show your working clearly.

(b) Using your answer to part (a), calculate the concentration, in mol l^{-1}, of chloride ions in this sample. **2**

Show your working clearly.

Q9 A student was asked to carry out an experiment to determine the concentration of a copper(II) sulfate solution.

Part of the work card used is shown.

> Determination of the Concentration of Copper(II) Sulfate Solution
>
> 1. Weigh an empty crucible
> 2. Add 100 cm^3 copper(II) sulfate solution
> 3. Evaporate the solution to dryness
> 4. Weigh the crucible containing dry copper(II) sulfate

(a) Suggest how the student could have evaporated the solution to dryness. **1**

(b) The student found that the 100 cm^3 solution contained 3·19 g of copper(II) sulfate, $CuSO_4$.

Calculate the concentration of the solution in mol l^{-1}. **2**

Show your working clearly.

Q10 Vinegar is an aqueous solution of ethanoic acid.

(*a*) A vinegar contains 6 g of ethanoic acid, CH_3COOH, in 100 cm^3 of solution.

Calculate the concentration in mol l^{-1} of this solution? **2**

Q11 Rust, iron(III) oxide, that forms on cars can be treated using rust remover which contains phosphoric acid.

When painted on, rust remover changes iron(III) oxide into iron(III) phosphate.

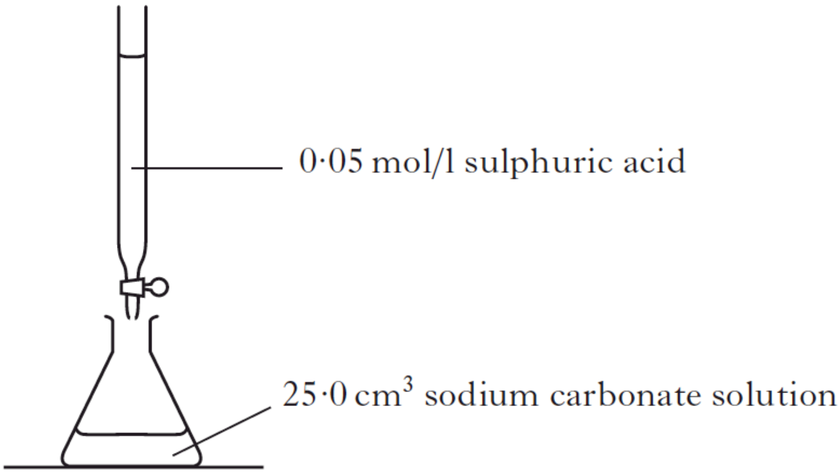
$$Fe_2O_3 + 2H_3PO_4 \longrightarrow 2FePO_4 + 3H_2O$$

(*a*) The rust remover contains 250 cm^3 of 2 mol l^{-1} phosphoric acid.

(i) Calculate the number of moles of phosphoric acid in the rust remover. **1**

(ii) Using your answer in part (i), calculate the mass of iron(III) oxide that will be removed by 250 cm^3 of 2 mol l^{-1} phosphoric acid. **2**

Q12 (*b*) Another experiment involved determining the concentration of sodium carbonate solution by titration.



The results showed that 20 cm^3 of sulphuric acid was required to neutralise the sodium carbonate solution.

(i) Calculate the number of moles of sulphuric acid in this volume. **1**

(ii) One mole of sulphuric acid reacts with one mole of sodium carbonate.

Using your answer from part (*b*)(i), calculate the concentration, in mol/l, of the sodium carbonate solution. **1**

Q13 (b) Nonane burns to produce carbon dioxide and water.

$$C_9H_{20} + 14O_2 \longrightarrow 9CO_2 + 10H_2O$$

Calculate the mass, in grams, of carbon dioxide produced when 32 g of nonane is burned. **3**

Show your working clearly.

Q14 A student investigated the reaction of carbonates with dilute hydrochloric acid.

(b) In another reaction 1 g of calcium carbonate reacted with excess dilute hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(\ell)$$

(i) Calculate the mass, in grams, of carbon dioxide produced. **3**

Q15 Nitrogen trifluoride, NF_3, is used in the manufacture of plasma screens.

(*c*) The equation for the formation of nitrogen trifluoride, NF_3, is:

$$N_2 + 3F_2 \longrightarrow 2NF_3$$

Calculate the mass of nitrogen trifluoride produced from 7 g of nitrogen.

Show your working clearly. **2**

Q16 Ammonium sulphate is a commonly used fertiliser. It can be produced by the reaction between ammonium carbonate and calcium sulphate.

$$(NH_4)_2CO_3(aq) + CaSO_4(aq) \longrightarrow (NH_4)_2SO_4(aq) + CaCO_3(s)$$

(*a*) Name this type of chemical reaction.

____ **1**

(*b*) What mass of ammonium carbonate, $(NH_4)_2CO_3$, would be needed to make 13·2 kg of ammonium sulphate, $(NH_4)_2SO_4$? **2**

Q17 Ammonia is a compound of nitrogen and hydrogen.

(*c*) Ammonia, a weak base, can be used to make the fertiliser ammonium phosphate.

$$3NH_3 + H_3PO_4 \longrightarrow (NH_4)_3PO_4$$

(ii) Calculate the mass of ammonium phosphate that would be produced from 510 g of ammonia. **2**

Q18 Fats and oils are examples of esters. The structure of the fat glyceryl tristearate is shown below.

(*c*) The equation below shows the breakdown of glyceryl tristearate to form glycerol and stearic acid.

$C_{57}H_{110}O_6$	+	$3H_2O$	$\longrightarrow$	$C_3H_8O_3$	+	$3C_{18}H_{36}O_2$
glyceryl tristearate		water		glycerol		stearic acid
GFM = 890 g						

Calculate the mass of stearic acid produced from 8·9 g of glyceryl tristearate. **2**

Q19 (*b*) Silver tarnishes in air forming black silver sulphide, Ag_2S.

The equation for the reaction is:

$$4Ag + 2H_2S + O_2 \longrightarrow 2Ag_2S + 2H_2O$$

What mass of silver sulphide would be formed from 1·08 g of silver? **2**

Q20 (*b*) The equation for the reaction is:

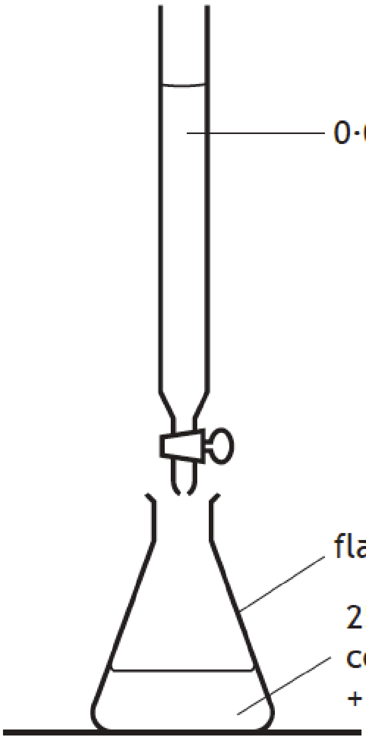
$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

In the experiment 50 cm^3 of sodium hydroxide solution reacted with 20 cm^3 0·1 $mol\,l^{-1}$ dilute sulphuric acid.

Calculate the concentration of the sodium hydroxide solution. **2**

Q21 Vitamin C is found in fruits and vegetables.

Using iodine solution, a student carried out titrations to determine the concentration of vitamin C in orange juice.



The results of the titration are given in the table.

Titration	*Initial burette reading* (cm^3)	*Final burette reading* (cm^3)	*Titre* (cm^3)
1	1·2	18·0	16·8
2	18·0	33·9	15·9
3	0·5	16·6	16·1

(a) Calculate the average volume, in cm^3, that should be used in calculating the concentration of vitamin C. **1**

(b) The equation for the reaction is

$$C_6H_8O_6(aq) + I_2(aq) \longrightarrow C_6H_6O_6(aq) + 2HI(aq)$$

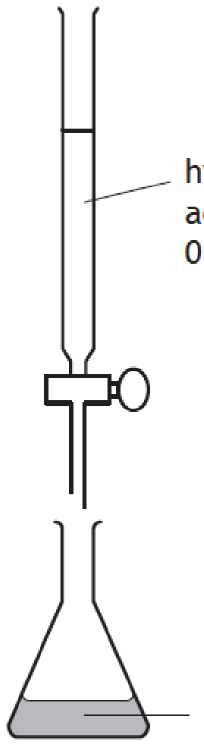
vitamin C

Calculate the concentration, in mol l^{-1}, of vitamin C in the orange juice. **3**

Show your working clearly.

Q22 Sodium carbonate solution can be added to the water in swimming pools to neutralise the acidic effects of chlorine.

A student carried out a titration experiment to determine the concentration of a sodium carbonate solution.



	Rough titre	*1st titre*	*2nd titre*
Initial burette reading (cm^3)	0·0	0·0	0·0
Final burette reading (cm^3)	16·5	15·9	16·1
Volume used (cm^3)	16·5	15·9	16·1

(a) Using the results in the table, calculate the average volume, in cm^3, of hydrochloric acid required to neutralise the sodium carbonate solution. **1**

(b) The equation for the reaction is

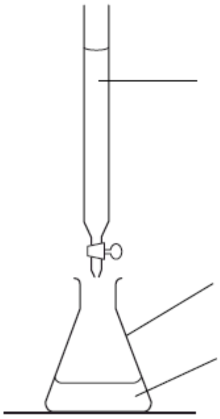
$$2HCl + Na_2CO_3 \longrightarrow 2NaCl + CO_2 + H_2O$$

Using your answer from part (a) calculate the concentration, in mol l^{-1}, of the sodium carbonate solution. **3**

Show your working clearly.

Q23 **(c) (continued)**

Using bromine solution, a student carried out titrations to determine the concentration of limonene in a household cleaner.



Titration	Initial burette reading (cm^3)	Final burette reading (cm^3)	Titre (cm^3)
1	0·5	17·1	16·6
2	0·2	16·3	16·1
3	0·1	16·0	15·9

(i) What colour change would be seen in the flask that indicates the end point of the titrations?

____________________ to ____________________ **1**

(ii) What average volume should be used in calculating the concentration of limonene?

__________ cm^3 **1**

(iii) The equation for the reaction between limonene and bromine solution is shown.

$$C_{10}H_{16}(aq) + 2Br_2(aq) \longrightarrow C_{10}H_{16}Br_4(aq)$$

Calculate the concentration of limonene in the household cleaner. **2**

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Q1	a		gfm = 60 1 mark 28/60 × 100 1 mark Final answer 46·6% 1 mark 46·6 / 46·7 / 47 on its own 3 marks	3	Allow follow through from incorrect gfm Do not allow 46 on its own

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Question			Answer	Max Mark	Additional Guidance
Q2	(b)		70 with no working (3) GFM = 160g (1) 112 / 160 x 100 (1) = 70 (1)	**3**	If atomic numbers are used with working shown (68•4 %) maximum 2 marks 68•4 on its own - 0 marks Allow follow through If candidate correctly calculates percentage of oxygen (30%) rather than iron maximum 2 marks but working must be shown 30% on its own zero marks Unit not required however if wrong unit given do **not** award mark for final answer.

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Question			Acceptable Answers	Mark	Unacceptabl
Q3	a		Heat alone (Reacting with) carbon Electrolysis	**1 or 0**	
Q3	b	i	FM = 232·5 (1) 200·5/232·5 x 100 = 86·2% or 86% (1) 86·2% or 86% on its own 2 marks Use of atomic numbers max 1 mark, must have working to gain the mark, 83·3% Incorrect rounding (with working) –(½) Metal other than Hg max 1 mark	**2**	

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Question		Acceptable Answer		Mark	Unacceptable Answer
Q4	(a)	$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$ Or correct multiples		1	
	(b)	neutralisation		1	
	(c)	FM = 174g	(1 mark)	2	44 on its own zero If use element not in potassium sulphate – zero marks
		78/174 × 100 = 44.8	(1 mark)		
		44.8 or 45 on its own	2 marks		
		Deduct ½ mark for arithmetic error Using atomic numbers 44% (max 1 mark) 44 must have working If use mass of one potassium max 1 mark If use S or O max 1 mark			

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Question			Answer	Max Mark	Additional Guidance
Q5	(a)		Potassium is an essential element or humans / human body cannot store it / have no mechanism for storing it	1	
	(b)		0·022 or 0·02 (moles) **with no working** (2) 0·86 / 39 = (1) 0·022 or 0·02 (moles) (1)	2	Any incorrect answer with **no working** award zero marks Allow follow through if incorrect value extracted from text and correctly divided by 39. 39/0·86 = 45·34 1 mark 0·86/100 = 0·0086 1 mark 100/39 = 2·56 1 mark Any other response zero marks If incorrect unit used maximum of 1 mark awarded Accept mol(s) Do not accept ml, g

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Q6	a		$\frac{1{\cdot}57}{157}$ = 0·01 moles 0·01 moles on its own	1	½ mark – working only $\frac{1{\cdot}57}{157}$ ½ mark – arithmetic error

Q7	(c)	$\frac{1.8}{90}$ ½ = 0.02 or 1/50 ½ Or 0.02 or 1/50 on its own 1	1	$\frac{1.8}{90}$ only Arithmetic mistake No follow through

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Q8	a		gfm 143·5g 1 mark 1·435 / 143·5 = 0·01 mol 1 mark 0·01 mol on its own 2 marks	2	Allow follow through if gfm incorrect
Q8	b		Answer from part (a) / 0·02 1 mark Correct answer 1 mark 0·01 / 0·02 1 mark = 0·5 mol l^{-1} 1 mark 0·5 mol l^{-1} on its own 2 marks	2	Allow follow through from answer to part (a) If correct relationship but volume not converted to litres eg 0·01/20 max 1 Mark

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Question			Acceptable Answer(s)	Max Mark	½ mark	Unacceptable
Q10	a		gfm = 60g ½ Moles = 6/60 = 0·1 (moles) ½ C = 0·1/0·1 = 1 (moll^{-1}) 1 Accept follow through Minus ½ mark arithmetic error correct working but incorrect answer	2		$\frac{0.1}{100}$ x1000 Does not get 2nd mark

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Question			Answer	Max Mark	Additional Guidance
Q9	(a)		Boil it **or** boil off the water **or** heat it **or** leave it for some time/overnight/next lesson **or** leave it on the window ledge **or** use Bunsen (burner) **or** appropriate diagram	**1**	Any mention of filtering negates the correct answer. Refer to General Marking Principle **(g)** for guidance. Award zero marks for leave it with no indication of appropriate time or do nothing. Award zero marks awarded for mention of burn **or** burning. This negates the correct answer.
Q9	(b)		0·2 with no working (2) .... Partial marking 3·19/159·5 = 0·02 (1) 0·02/0·1 = 0·2 (1) (this step on its own 2 marks) or (3·19 in 100 cm^3) 31·9 in 1000 cm^3 or 1 litre (1) 31·9/159·5 = 0·2 (1) (this step on its own 2 marks)	**2**	Allow follow through from step 1 Award 1 mark for 0·1 --> 3·19 1 --> 31·9 Zero marks are awarded for **only** showing c=n/v where the answer is not 0·2 Unit is not required however if the wrong unit is given a maximum of 1 mark out of 2 can be awarded. Accept mol l^{-1} or mol/l ('L' in place of 'l') Do not accept mol/l^{-1} or mol^{-1} or mol l

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Question	Acceptable Answer	Mark	Worth ½	Worth 0
Q11 (a) (i)	2 x 0.25 ½ = 0.5 ½ 0.5 no working 1	1	2 x 0.25 only/ Arithmetic mistake	2 x 250 = 500 2/250 = 0.008 (will give 0.64 as follow through) n=cv no working
(ii)	GFM Fe_2O_3 = 160 ½ Moles of Fe_2O_3 = $\frac{0.5}{2}$ = 0.25 or mole ratio stated ½ Fe_2O_3 : H_3PO_4 1 : 2 Mass of Fe_2O_3 = 0.25 X 160 ½ = 40 ½ Or 40 on its own (2) Allow follow through using number of moles from part (i) if show working If atomic number is used instead of mass – max 1 mark If use ratio 1:1 80g 1 ½ if show working			

Question	Acceptable Answers	Mark	Unacceptable Answers
Q12 b i	(n = c x V) n = 0·05 x 0·02 (½) n = <u>0·001</u> (½) If 20 cm^3 used in place of 0·02 (-½) Using wrong substance i.e. 0·025 (-½)	1	n = c x V on its own 1 on its own zero marks 0·01 on its own zero marks 25 cm^3 used as volume zero marks
Q12 b ii	Apply mole ratio 1:1 0·001 ⟶ 0·001 (½) 0·001 = c x 0·025 c = <u>0·04</u> (½) allow for follow through from (b) (i) Don't penalise for non-conversion to litres here if already penalised in (b) (i) PVC method can give an answer for b (ii) even if b (i) is wrong or blank … if correct 1 mark for b (ii) If 25 cm^3 used in place of 0·025 (-½) mark Using wrong substance i.e. 0·020 (-½) mark	1	20 cm^3 used as volume zero marks

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Question			Answer	Max Mark	Additional Guidance
Q13	(b)		99 with no working (3) 32/128 = 0·25 (1) 0·25 gives 2·25 (9 x 0·25) (1) (this step on its own 2 marks) 2·25 x 44 = 99 (1) (this step on its own 3 marks) -------------------------------------- - 128 g and 44 g both shown (1) 128 g gives 396 g (9 x 44) (1) (this step on its own 2 marks) 32 g gives 99 g [(396/128) x 32] (1) (this step on its own 3 marks) ------------------------------------- 128 g and 44 g both shown (1) 128 g gives 396 g (9 x 44) (1) (this step on its own 2 marks) 128/32 = 4 396/4 = 99 (1) (this step on its own 3 marks) Any other valid method accepted.	**3**	32/96 (mass of nonane incorrect) = 0·33 zero marks 0·33 x 9 = 2·97 1 mark correct follow through 2·97 x 44 = 130·68 1 mark correct follow This would be awarded 2 out of 3 marks -------------------------------------- - Any other answer without working = zero marks Unit not required however if wrong unit given do **not** award mark for final answer. If candidate uses incorrect mass for 9 moles CO_2 and has clearly shown working for this step maximum 2 marks can be awarded. If candidate uses incorrect mass for 9 moles of CO_2 and has shown no working for this step maximum of 1 mark can be awarded. This also applies to GFM of nonane.

Q14	a	ii	Li Cl formula/words/circled /highlighted in equation 1:1 ratio 1 mark 0·01 × 44 = 0·44 1 mark Units not required 1 mole gives 1 mole 1 mark 100 g gives 44 g 1 mark 1 g gives 44/100 = 0·44 1 mark 0·44 on its own 3 marks	1	

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Question	Acceptable Answers	Mark	Unacceptable Answers
Q15 c	1 mole N_2 = 28 g 7/28 = 0·25 moles (½) 0·25 to 0·5 (1 mole to 2 moles) (½) 1 mole NF_3 = 71 g (½ for **both** formula masses) 71 x 0·5 = <u>35·5</u> (½) **35·5 on its own 2 marks** 1 : 2 (½) 28 : 142 (½) 1 ⟶ 142/28 (½) 7 ⟶ 142 x 7/28 = <u>35·5</u> (½) or any other acceptable method	2	Use of any atomic number maximum 1 mark <u>if working is shown.</u> If no working is shown then zero marks. (Possible answers using atomic numbers in one or both formula masses: 34 g, 71 g, 17 g.) Using $2NF_3$ as 2N and 3F to calculate FM (85) max 1 mark 28 → 85 7 → 21·25

Question	Acceptable Answer	Mark	Worth ½
Q16 (a)	Precipitation (ignore spelling)	1 or 0	
(b)	1 mole $(NH_4)_2SO_4$ = 132 g ½ Moles of $(NH_4)_2SO_4$ = $\frac{13200}{132}$ = 100 moles ½ Moles of $(NH_4)_2CO_3$ = 100 ½ Moles of $(NH_4)_2CO_3$ = 100 × 96 = 9600 g/9·6 kg ½ OR $(NH_4)_2CO_3$ 1 mole — $(NH_4)_2SO_4$ 1 mole ½ 96 g — 132 g ½ $\frac{13200}{132} \times 96$ — 13200 g = 9600 g/9·6 kg 1 -½ for 9600 kg 9600 g or 9.6 kg on its own – 2 marks accept working in grams and conversion to kg at end 13·2/132 = 0·1 0·1 × 96 = 9·6 kg no ½ mark for GFM $(NH_4)_2CO_3$ = 96 g	2	-½ per arithmetic mistake -½ for incorrect conversion to kg penalise once only -1 if used atomic numbers -1 if incorrect chemical or formula is used in calculation

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Question			Acceptable Answer(s)	Max Mark	½ mark	Unacceptable
Q17	c	ii	gfm NH_3=17g ½ moles of NH_3 =510/17=30 moles ½ moles of $(NH_4)_3PO_4$ =30/3=10 moles ½ Mass of $(NH_4)_3PO_4$ =10x149=1490 grams ½ OR $3NH_3 \longrightarrow (NH_4)_3PO_4$ 3 mole 1mole ½ 3 x17 ½ 51 ⟶ 149 ½ 510 ⟶ 1490 ½ Accept follow through Correct answer but no working 2 If use wrong formula or wrong substance then -1 mark so max is 1 mark NH_3 to H_3PO_4 = 980 H_3PO_4 to $(NH_4)_3PO_4$ = 775.4	2		

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Q18	c		$\frac{8 \cdot 9}{890}$ 0·01 mole ½ 0·01 × 3 = 0·03 moles ½ GFM stearic acid = 284 ½ Mass of stearic acid = 0·03 × 284 = 8·52 ½ 1mole → 3 moles ½ 890g → 3 × 284g (½ for GFM for stearic acid) 8.9→ $\frac{8.9}{890}$ (½) × 852g (3 × 284) Mass of stearic acid = 8.52g ½	2	Allow follow through if made a mistake in calculation/ arithmetic error

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Question	Acceptable Answer	Mark	Worth ½	Worth 0
***Q19* (b)**	4 moles to 2 moles 4 × 108g = 2 × 248	½	-½ mark per arithmetic mistake, even if correct final answer is given	If they only have calculated the GFM for Ag_2S (as 248)
	432 = 496 1·08 = 1·08 × 496/432	½	-1 mark if atomic numbers are used	
	= 1·24	**1**	-1 mark if incorrect chemical used in calculation	
	OR			
	no of moles of Ag = 1·08/108 = 0·01 moles	½		
	no of moles of Ag_2S = 0·01/2 = 0·005	½		
	GFM Ag_2S = 248 Mass of Ag_2S = 0·005 × 248 = 1·24	**1**		
	Ignore units/absence of units/ incorrect units given Check paper for indication of final answer.			

Question	Acceptable Answer	Mark	Worth ½
***Q20* (b)**	Moles of acid = C × V = 0·1 × 0·02		-½ per arithmetic error
	= 0·002	½	-½ if cm^3 used instead of litres only in method 1
	1 mole to 2 moles	½	
	moles of NaOH = 0·002 × 2 = 0·004 c = n/v = 0·004/0·05		
	= 0·08	**1**	
	OR		
	H × C × V = OH × C × V		
	2 × 0·1 × 20 = 1 × C × 50	½	-½ if cm^3 and litres mixed in method 2/3
	4 = 50C	½	
	C = 4/50	½	
	= 0·08	½	
	OR		
	$\frac{C_A V_A}{C_B V_B} = \frac{b}{a}$		
	$\frac{0.1 \text{ x} 20}{C_B \text{ x } 50} = \frac{1}{2}$	½	
	$C_B = \frac{0.1 \text{ x } 20 \text{x } 2}{50}$	½	
	$= \frac{4}{50}$	½	
	= 0.08	½	

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Question			Answer	Max Mark	Additional Guidance
Q21	(a)		16	**1**	Unit is not required however if the wrong unit is given do **not** award mark.
	(b)		0·0032/3·2 x 10^{-3} with no working or correctly rounded answer (3) .... Partial marking 0·0050 x 0·016 = 0·00008 mol I_2 (1) 0·00008 mol of Vit C (1) (this step on its own gets 2 marks) 0·00008/0·025 = 0·0032/3·2 x 10^{-3} (1) (this step on its own gets 3 marks) **or** 0·0050 x 16 = 0·08 mol I_2 (1) 0·08 mol of Vit C (1) (this step on its own gets 2 marks) 0·08/25 = 0·0032/3·2 x 10^{-3} (1) (this step on its own gets 3 marks) or $\frac{C_1 \times 25}{1} = \frac{0{\cdot}0050 \times 16}{1}$ (1) (1) C_1 x 25 = 0·08 (this step on its own gets 2 marks) C_1 = 0·0032/3·2 x 10^{-3} (1) (this step on its own gets 3 marks) or $\frac{C_1 \times 0.025}{1} = \frac{0{\cdot}0050 \times 0.016}{1}$ (1) (1) C_1 x 0.025 = 0·00008 (this step on its own gets 2 marks) C_1 = 0·0032/3·2 x 10^{-3} (1) (this step on its own gets 3 marks) OR ANY OTHER ACCEPTABLE METHOD	**3**	Allow follow through from part 15(a). Refer to General Marking Principle **(k)** for guidance. Candidates should not be penalised if 16 (or volume from part a) **and** 25 (volume of vitamin C solution) are both expressed in cm^3. If candidate expresses one volume in cm^3 and the other in litres then a maximum of two marks can be awarded. If candidate **only** calculates number of moles of iodine the volume must be in litres to be awarded 1 mark i.e. 0·0050 x 16 = 0·08 mol I_2 on its own with no further working is awarded zero marks. Zero marks are awarded if values for C, V and n are given but not used in an appropriate method. For method using relationship shown in the data book 1 mark is awarded for the correct pairings of volume (in the same unit) and concentration. 1 mark is awarded for the correct mole ratio being applied. 1 mark is awarded for the correct arithmetic. This mark can only be awarded if an appropriate method has been used. Unit is not required however if the wrong unit is given then the final mark cannot be awarded. Accept mol l^{-1} or mol/l but **not** mol/l^{-1} or mol^{-1} or mol l

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Question			Answer	Max Mark	Additional Guidance
Q22	(a)		16	**1**	Unit not required however if wrong unit given do **not** award mark for final answer.
	(b)		0·08 with no working 3 marks 0·1 x 0·016 = 0·0016 (1) 0·0016/2 = 0·0008 (1) 0·0008/0·01 = 0·08 (1) 0·08 on its own 3 marks or $\frac{0{\cdot}1 \times 16}{2} = \frac{C_2 \times 10}{1}$ (1) 0·8 = C_2 x 10 (1) C_2 = 0·08 (1) or any alternative correct method	**3**	Allow follow through from part (a) For the first method shown candidates should not be penalised if 16 (or volume from part a) and 10 (volume of sodium carbonate solution) are both expressed in cm^3. If candidate **only** calculates number of moles of acid the volume must be in litres to be awarded 1 mark. If candidate correctly divides their number of moles of acid by 2 the mark for the mole ratio can be awarded. Unit not required however if wrong unit given do **not** award mark for final answer. Accept mol l^{-1} or mol/l but not mol/l^{-1} or mol^{-1} or mol l If concentration of incorrect chemical is calculated then max= 1 mark

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Question	Acceptable Answer	Mark	Worth ½	Worth 0
Q23 (c) (i)	colourless to orange/brown/red/yellow/any combination must be correct way round both colours required for 1 mark	**1 or 0**		clear pink
(ii)	16·0/ 16	**1 or 0**		16·2 cm^3
(iii)	moles of Br_2 = 0·5 × 0·016 = 0·008 ½ moles of $C_{10}H_{16} = \frac{0\cdot008}{2} = 0\cdot004$ ½ concentration of $C_{10}H_{16} = \frac{0\cdot004}{0\cdot02}$ ½ = 0·2 ½ Correct answer but no working = 2 marks Or 0·2025 (if 16·2 used) = 0·20/0·203 if rounded Allow follow through for incorrect answer above. $\frac{20 \times c_1}{1} = \frac{16 \times 0\cdot5}{2}$ 1 mark $40 \times c_1 = 8$ $c_1 = 0\cdot2$ 1 mark (-½ if incorrect ratio is used)	**2**	-½ per arithmetic mistake -½ for using cm^3 and not litres if first method is used	