IGCSE Edexcel Chemistry Revision

Revision Guide Section 3: Equations and Calculations

Paper 1 [All Pathways]

Please note, these questions may have parts related to **other** topics within the GCSE Chemistry course. However, all questions are related at least in part to Equations and Calculations.

Questions taken from 2019 and 2020 January, June and November Papers (C and CR)

- 6 questions
- 77 marks
- Recommended time for all questions: 85 minutes (just over 1 minute per mark)

1. A student uses the reaction between zinc and dilute sulfuric acid to prepare some zinc sulfate crystals.

(a) (i) Complete the equation for this reaction by giving the correct state symbols. (1)

Zn (.....) + H_2SO_4 (.....) → $ZnSO_4$ (.....) + H_2 (.....)

(ii) State what would be observed during this reaction. (1)

.....

.....

(b) The student adds excess zinc to a beaker of dilute sulfuric acid.

(i) Explain why it is necessary to add excess zinc. (2)

.....

.....

.....

.....

(ii) Draw a diagram of the apparatus the student should use to remove the unreacted zinc and collect the zinc sulfate solution. (2)

(c) The student obtains a pure, dry sample of zinc sulfate crystals.
The formula of zinc sulfate crystals is $ZnSO_4.7H_2O$

(i) Calculate the relative molecular mass (M_r) of zinc sulfate crystals. (2)

M_r = ...

(ii) The student uses 0.0200 mol of dilute sulfuric acid in her preparation.
Show that the maximum mass of zinc sulfate crystals that the student could obtain is about 6 g. (2)

(iii) The student obtains a mass of 4.28 g of zinc sulfate crystals.
Calculate the percentage yield of the zinc sulfate crystals.
Give your answer to three significant figures. (3)

percentage yield = ... %

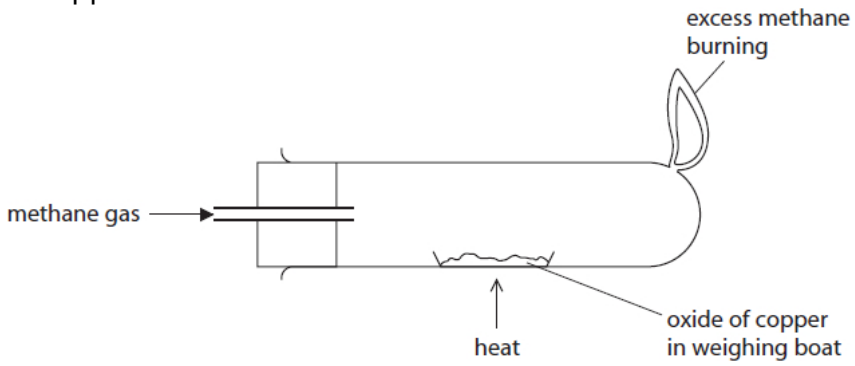
(Total for question = 13 marks)

2. This question is about the reduction of metal oxides.

(a) Solid oxides of copper can be reduced by reacting them with methane gas.
Complete the equation for the reaction between copper(II) oxide and methane.
Include state symbols. (2)

.....CuO(.....) + ...CH_4(.....) → .....Cu(.....) + ...CO_2(.....) + ...H_2O(.....)

(b) A teacher uses this apparatus to demonstrate the reaction between a different oxide of copper and methane.



(i) The teacher heats the oxide of copper until the reaction is complete.
The table shows the teacher's results.

	Mass in g
empty weighing boat	15.05
weighing boat + oxide of copper	18.63
weighing boat + copper	18.23

Use the teacher's results to show that the empirical formula of this oxide of copper is Cu_2O (4)

(ii) The teacher wears safety glasses and a lab coat during the demonstration.
Give one other safety precaution that she should take. (1)

.....

.....

(c) Iron forms when iron(III) oxide is heated with carbon.
The equation for the reaction is

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

(i) State how the equation shows that iron(III) oxide is reduced. (1)

.....

.....

(ii) State why carbon monoxide should not be released into the atmosphere.(1)

.....

.....

(iii) Calculate the maximum mass, in tonnes, of iron that can be produced when 30.0 tonnes of iron(III) oxide are reacted with an excess of carbon.
[1 tonne = 1.0×10^6 g] (4)

mass = ... tonnes

(iv) A mixture of 25 000 mol of iron(III) oxide and 840 000 g of carbon is heated.
Use this equation to show that the iron(III) oxide is in excess.
$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$ (2)

(Total for question = 15 marks)

3. Nitric acid (HNO_3) is used in the production of fertilisers.
Nitric acid is manufactured in three stages.

Stage 1	ammonia reacts with oxygen in the presence of a platinum catalyst to produce nitrogen monoxide gas, NO, and water.
Stage 2	nitrogen monoxide gas reacts with more oxygen to produce nitrogen dioxide gas, NO_2.
Stage 3	nitrogen dioxide gas reacts with water to produce nitric acid and more nitrogen monoxide gas.

(a) (i) Complete the chemical equation for the reaction in stage 1. (1)

..... NH_3 + ... O_2 $\rightleftharpoons$ ..... NO + ... H_2O

(ii) Give the meaning of the symbol $\rightleftharpoons$ (1)

.....

.....

(iii) State the purpose of the platinum catalyst. (1)

.....

.....

(b) Give a chemical equation for the reaction of nitrogen monoxide and oxygen in stage 2. (1)

.....

(c) (i) The equation for the reaction in stage 3 is

$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$$

Calculate the maximum mass, in tonnes, of nitric acid that could be produced in this reaction from 11.5 tonnes of nitrogen dioxide.
[1 tonne = 1.0×10^6g] (4)

mass of nitric acid = ... tonnes

(ii) Suggest what use can be made of the nitrogen monoxide gas formed in stage 3. (1)

.....

.....

(d) When copper(II) oxide reacts with dilute nitric acid, copper(II) nitrate is produced.
The equation for the reaction is

$$CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$$

0.200 mol of nitric acid reacts with excess copper(II) oxide.
A mass of 15.3 g of copper(II) nitrate is produced.
Calculate the percentage yield of copper(II) nitrate.
[M_r of copper(II) nitrate = 187.5] (3)

percentage yield = ... %

(Total for question = 12 marks)

4. Sodium hydrogencarbonate ($NaHCO_3$) is also known as baking soda.
Baking soda can be used to make cakes increase in size in an oven.
This is the equation for the reaction that takes place when baking soda is heated.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

(a) (i) What type of reaction is this? (1)

- ☐ A combustion
- ☐ B decomposition
- ☐ C oxidation
- ☐ D reduction

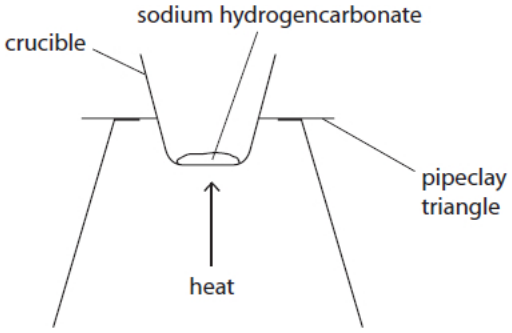
(ii) Suggest why the reaction makes the cakes increase in size. (1)

.....

.....

.....

(b) A student uses this apparatus to investigate the reaction that takes place when sodium hydrogencarbonate is heated.



This is the student's method.

- weigh a crucible and record the mass
- add some sodium hydrogencarbonate to the crucible, reweigh it and record the mass
- heat the crucible and contents for five minutes, then allow to cool before weighing and recording the mass
- heat the crucible and contents again for a further three minutes, then allow to cool before weighing and recording the mass

(i) Give a reason why the crucible and contents are heated for a further three minutes. (1)

.....

.....

.....

(ii) The student considered using a lid on the crucible in the experiment. Suggest an advantage and a disadvantage of using a lid on the crucible. (2)

Advantage .....

.....

.....

Disadvantage .....

.....

.....

(c) The table shows some of the student's results.

mass of crucible and sodium hydrogencarbonate in g	29.75
mass of empty crucible in g	26.50

(i) Calculate the mass of sodium hydrogencarbonate that the student uses. (1)

mass = ... g

(ii) Using this equation, calculate the maximum mass of sodium carbonate (Na_2CO_3) that could form in the student's reaction.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

[M_r of $NaHCO_3$ = 84 M_r of Na_2CO_3 = 106 (3)

maximum mass = ... g

(d) In a second experiment, the student uses a larger mass of sodium hydrogencarbonate.
She calculates that she should obtain 4.8 g of sodium carbonate.
She actually obtains 4.2 g of sodium carbonate.

(i) Calculate the percentage yield from the student's experiment. (2)

percentage yield = ... %

(ii) Other than spillages, suggest a possible reason why the student's actual yield is less than expected. (1)

.....

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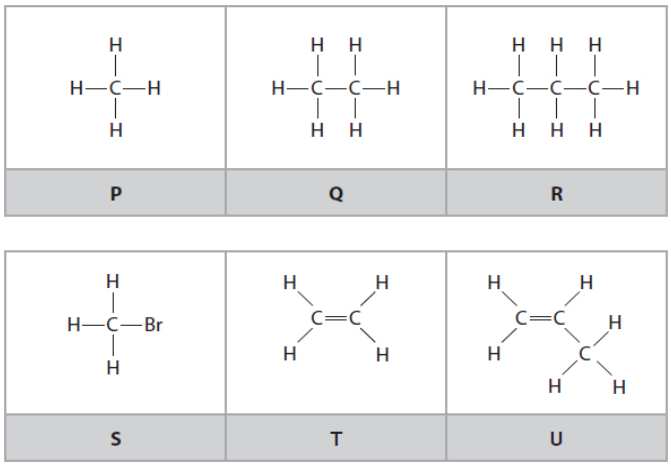
.....

(Total for question = 12 marks)

5. The boxes show the displayed formulae of six organic compounds, P, Q, R, S, T and U.



(a) Use the letters P, Q, R, S, T and U to answer these questions.
Each letter may be used once, more than once or not at all.

(i) Give the letter of the compound that is not a hydrocarbon. (1)

.....

(ii) Give the letters of the two compounds that have the same empirical formula. (1)

.....

(iii) Give the letter of the compound that is used to manufacture poly(propene). (1)

.....

(b) Describe a test that can be used to distinguish between compounds Q and T. (3)

Test .....

.....

Result with compound Q .....

.....

Result with compound T.....

.....

(c) Compounds P, Q and R are members of the same homologous series.
Give two characteristics of a homologous series. (2)

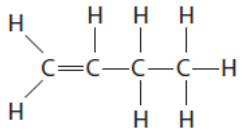
1 .....

.....

2 .....

.....

(d) This is the displayed formula of an alkene, V.



(i) Give the name of alkene V. (1)

.....

(ii) Draw the displayed formula of another alkene that is an isomer of alkene V.
(1)

(e) An organic compound has the percentage composition by mass
C = 36.36% H = 6.06% F = 57.58%

(i) Show that the empirical formula of the compound is CH_2F (2)

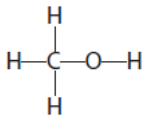
(ii) The relative molecular mass (M_r) of the compound is 66.
Determine the molecular formula of the compound. (2)

molecular formula = ...

(Total for question = 14 marks)

6.

(a) The diagram shows the displayed formula of the organic compound methanol, CH_3OH



(i) Determine the number of atoms in one molecule of methanol. (1)

.....

(ii) State why methanol is not a hydrocarbon. (1)

.....

.....

(b) The atoms in methanol are held together by covalent bonds.

(i) State what is meant by the term covalent bond. (2)

.....

.....

.....

.....

(ii) Draw a dot-and-cross diagram to show the bonding in a molecule of methanol.
Show only the outer electrons of each atom. (2)

(c) Another organic compound has the percentage composition by mass

C = 38.7% H = 9.7% O = 51.6%

(i) Calculate the empirical formula of this compound. (3)

empirical formula = ...

(ii) The relative molecular mass (M_r) of the compound is 62
Determine the molecular formula of the compound. (2)

molecular formula = ...

(Total for question = 11 marks)

END OF QUESTIONS

Mark Scheme

Q1.

Question number	Answer	Notes	Marks
(a) (i)	$Zn\ (s) + H_2SO_4\ (aq) \rightarrow ZnSO_4\ (aq) + H_2\ (g)$	**ACCEPT** upper case letters	1
(ii)	effervescence/bubbles/fizzing	**ACCEPT** zinc gets smaller or disappears **IGNORE** hydrogen / gas produced / given off	1
(b) (i)	An explanation that links the following two points **M1** to make sure all of the acid reacts **M2** (so that) a pure zinc sulfate solution is obtained/pure zinc sulfate crystals are obtained OWTTE		2
(ii)	**M1** filter funnel containing filter paper **M2** suitable container to collect filtrate e.g. beaker, conical flask, evaporating basin	**M2** dep on a filter funnel in **M1**	2

Question number	Answer	Notes	Marks
(c) (i)	• setting out of calculation • evaluation Example calculation **M1** 65 + 32 + (4 x 16) + (7 x 18) **M2** 287	correct answer without working scores 2	2
(ii)	• multiply moles by M_r • evaluation Example calculation **M1** (mass of $ZnSO_4.7H_2O$ =) 287 x 0.02(00) **M2** (mass of $ZnSO_4.7H_2O$ =) 5.74 (g)	correct answer (5.74) without working scores 2 **ALLOW** ecf from (i)	2
(iii)	**M1** 4.28÷5.74 OR 0.7456 **M2** 0.7456 × 100 **M3** 74.6	correct answer to 3 sig figs without working scores 3 **ALLOW** ecf from (ii) **ALLOW** use of 6g **ALLOW** any number of sig fig greater than 1 **ALLOW** use of 6g giving answer of 71.3 Must be 3 sig figs to score M3	3
			Total 13

(**Q07 4CH1/1CR, Nov 2020**)

Q2.

Question number	Answer	Notes	Marks
(a)	**4** CuO **(s)**+ CH_4 **(g)**→ **4** Cu **(s)**+ CO_2 **(g)** + **2** H_2O **(l/g)** **M1** correct balancing **M2** correct state symbols	**ALLOW** multiples and fractions	2
(b) (i)	**M1** Mass copper 3.18g **and** mass oxygen 0.40g **M2** Moles copper = 3.18/63.5 **OR** 0.0500 moles **M3** Moles oxygen = 0.40/16 **OR** 0.025 moles **M4** Ratio of moles Cu:O is 2:1	 **M2** and **M3** allow ecf from **M1** **M4** is dep on **M2** and **M3**	4
(ii)	Any one from: **M1** Use a safety screen **M2** Position the class some distance from the apparatus **M3** Do the experiment in a fume cupboard **M4** Set fire to the (excess) methane gas straight away	 **ALLOW** tie hair back **ALLOW** wear heat-proof gloves	1
(c)(i)	(Iron (III) oxide) loses oxygen	**ALLOW** iron loses oxygen **IGNORE** any reference to electrons.	1
(ii)	Carbon monoxide is poisonous / toxic **OR** carbon monoxide reduces the ability of the blood to carry oxygen	**ALLOW** carbon monoxide binds to haemoglobin in the blood	1
(iii)	• calculate M_r of Fe_2O_3 • calculate the amount, in moles, of Fe_2O_3 • calculate the amount, in moles, of Fe • calculate the mass in tonnes of Fe Example calculation **M1** M_r of Fe_2O_3 = 160 **M2** $n(Fe_2O_3)$ = 30.0 x 10^6 ÷ 160 **OR** 187,500 moles **M3** n(Fe) = 187,500 x 2 **OR** 375,000 moles **M4** 375,000 x 56 = 21 tonnes	Correct answer of 21 tonnes scores 4 marks with or without working **ALLOW** ecf from **M1** (incorrect M_r) **ALLOW** working in megamoles **ALLOW** ecf from M1 **ALLOW** working in megamoles **ALLOW** ECF from M2 **ALLOW** ecf from M3	4
(iv)	**M1** 840,000g is 70,000 moles of carbon **M2** therefore need 23,333 moles Fe_2O_3 (but we have 25,000 which is an excess) **OR** **M1** Need 75,000 moles carbon **M2** 900,000g of carbon is needed (and have 840,000g of carbon so iron(III) oxide is in excess as carbon is the limiting reactant) **OR** **M1** need 75,000 moles of carbon **M2** have 840,000÷12 **OR** 70,000 moles of carbon (so iron(III) oxide is in excess as carbon is the limiting reactant)		2

(**Q11 4CH1/1CR, Jan 2020**)

Q3.

Question number	Answer	Notes	Marks
(a) (i)	$4NH_3 + 5O_2 \rightleftharpoons 4NO + 6H_2O$	**ACCEPT** multiples and fractions	1
(ii)	reversible (reaction)	**ACCEPT** reaction that goes both ways / both forwards and backwards reactions occur **IGNORE** references to equilibrium	1
(iii)	to increase the rate of the reaction / to speed up the reaction OWTTE	**IGNORE** references to lowering the activation energy	1
(b)	$2NO + O_2 \rightarrow 2NO_2$	**ACCEPT** multiples and fractions	1
(c) (i)	• calculate M_r of NO_2 and HNO_3 • calculate the amount, in moles, of NO_2 • calculate the amount, in moles, of HNO_3 • calculate the mass in tonnes of HNO_3 Example calculation M1 M_r of NO_2 = 46 M_r of HNO_3 = 63 M2 $n(NO_2) = 11.5 \times 10^6 \div 46$ **OR** 250 000 (mol) M3 $n(HNO_3) = \frac{2 \times 250000}{3}$ **OR** 167 000 / 170 000 M4 (167 000 x 63 g) = 10.5 (tonnes)	**ALLOW** working in megamoles i.e. 11.5 ÷ 46 **OR** 0.25 **ALLOW** ECF from incorrect Mr of NO_2 calculator answer 166666.66 **ALLOW** working in megamoles i.e. $\frac{2 \times 0.25}{3}$ **OR** 0.167 / 0.17 **ALLOW** ECF from M2 10.5 (tonnes) with no working scores 4 **ACCEPT** 10.7 (if 170 000 used) **ALLOW** ECF from M3 **ALLOW** ECF from incorrect M_r of HNO_3	4
(ii)	can be (re)used in stage 2 / to make more nitrogen dioxide (in stage 2) / can be used to make more nitric acid	**IGNORE** can be recycled/reused unless qualified	1

Question number	Answer	Notes	Marks
(d)	• calculate the amount, in moles, of copper(II) nitrate • calculate the theoretical yield, in moles, of copper(II) nitrate • calculate the percentage yield Example calculation **M1** nCu(NO$_3$)$_2$ formed = 15.3 ÷ 187.5 **OR** 0.0816 **M2** theoretical nCu(NO$_3$)$_2$ = 0.200 ÷ 2 **OR** 0.100 **M3** (% yield) = $\frac{(0.0816 \times 100)}{(0.100)}$ = 81.6 (%) Alternative method • calculate the theoretical yield, in moles, of copper(II) nitrate • calculate the theoretical mass of copper nitrate that should be formed • calculate the percentage yield	**ALLOW** 0.082 **ACCEPT** 82 (%) Mark M3 CSQ on M1 and M2 40.8 scores 2	3
	Example calculation **M1** theoretical nCu(NO$_3$)$_2$ = 0.200 ÷ 2 **OR** 0.100 **M2** theoretical mass of copper nitrate = 0.1 x 187.5 = 18.75 **M3** (% yield) = $\frac{15.3}{18.75}$ x 100 = 81.6 (%)	**ALLOW** 18.8 **ACCEPT** 82 (%) Mark M3 CSQ on M1 and M2 40.8 scores 2 81.6(%) with no working scores 3 marks	**Total 12**

(**Q10 4CH1/1C, Jan 2020**)

Q4.

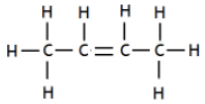
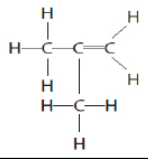
Question number	Answer	Notes	Marks
(a) (i)	**B** decomposition A is not correct because when sodium hydrogencarbonate is heated combustion does not take place C is not correct because when sodium hydrogencarbonate is heated oxidation does not take place D is not correct because when sodium hydrogencarbonate is heated reduction does not take place		1 comp
(ii)	(because) carbon dioxide/gas is produced/given off		1 grad
(b) (i)	to obtain a constant mass OWTTE / to show the reaction is complete OWTTE	ACCEPT to ensure only Na_2CO_3 is left (in crucible) ACCEPT to ensure all the $NaHCO_3$ has reacted /decomposed	1 exp
(ii)	M1 advantage: to stop any solid/Na_2CO_3/$NaHCO_3$ spitting out/being lost M2 disadvantage: the gas(es)/CO_2/H_2O/steam could not easily escape OWTTE	REJECT references to stopping gases escaping	2 exp

Question number	Answer	Notes	Marks
(c) (i)	3.25 (g)		1 exp
(ii)	• calculate moles of $NaHCO_3$ • use equation to determine moles of Na_2CO_3 • multiply by M_r to find mass of Na_2CO_3 Example calculation: M1 3.25 ÷ 84 **OR** 0.0387 (mol) M2 0.0387 ÷ 2 **OR** 0.01935 (mol) M3 0.01935 x 106 = 2.05 (g) **OR** • use of equation to relate mass of $NaHCO_3$ to mass of Na_2CO_3 • shows how to find mass of Na_2CO_3 using 3.25g $NaHCO_3$ • correct evaluation of answer Example calculation: M1 (2x84)/168 (g) $NaHCO_3$ → 106 (g) Na_2CO_3 M2 3.25 (g $NaHCO_3$)→ (106÷168) x 3.25 (g Na_2CO_3) M3 2.05 (g Na_2CO_3)	mark CQ on (i) ALLOW any number of sig figs except 1 2.05 (g) without working scores 3 marks 4.1 (g) without working scores 2 marks mark CQ on (i)	3 exp
(d) (i)	M1 percentage yield = 4.2÷4.8 **OR** 0.875 M2 = (0.875 x 100) = 87.5 (%)	ACCEPT 88 (%) Correct answer without working scores 2	2 grad
(ii)	any one from M1 sodium hydrogencarbonate was impure M2 not all sodium hydrogencarbonate reacted/decomposed		1 grad
		Total Q = 12 marks	

(**Q09 4CH1/1C, Nov 2020**)

Q5.

Question number	Answer	Notes	Marks
(a) (i)	S		1
(ii)	T and U		1
(iii)	U		1
(b)	A description that makes reference to the following three points **M1** (add) bromine water **M2** no change / stays orange **M3** (bromine water) decolourised / changes (from orange) to colourless	 **ACCEPT** Br_2 (aq) **ALLOW** no reaction If initial colour of bromine water is given in M2 or M3 it must be correct -ALLOW any combination of orange/yellow/brown - but penalise once only If bromine given for M1 then in M2 and M3 allow any combination of red/orange/brown/yellow **M2** and **M3** dep on bromine water/bromine in **M1** If no reagent and correct M2 and M3 - score 1 if incorrect reagent and correct M2 and M3 score 0 **IGNORE** clear **REJECT** discoloured **ALLOW M1** acidified potassium manganate(VII) **M2** no change/stays purple **M3** decolourised / goes colourless	3

Question number	Answer	Notes	Marks
(c)	Any **two** of the following points **M1** (can be represented by a) general formula **M2** each member differs from the next by a CH_2 group OWTTE **M3** (each member has) same functional group **M4** (each member has) similar/same chemical properties / similar/same (chemical) reactions **M5** trend in physical properties (between successive members)	 **ACCEPT** react in similar/same way **ACCEPT** named physical property, e.g. boiling point **REJECT** similar/same physical properties	2
(d) (i)	but-1-ene	**ALLOW** 1-butene	1
(ii)	**Either**  **Or** 	 **ACCEPT** cis or trans isomer **REJECT** displayed formulae of cyclic alkanes	1

Question number	Answer	Notes	Marks
(e) (i)	• Divide percentages by relative atomic masses • Divide results by smallest value to obtain ratio Example calculation **M1** C: $\frac{36.36}{12}$ H: $\frac{6.06}{1}$ F: $\frac{57.58}{19}$ **M2** $\frac{3.03}{3.03}$ $\frac{6.06}{3.03}$ $\frac{3.03}{3.03}$ **OR** 1 2 1	0 marks if division by atomic numbers or upside down calculation	2
(ii)	• divide relative molecular mass by empirical formula mass • correct molecular formula Example calculation **M1** $\frac{66}{12 + 2 + 19}$ **OR** $\frac{66}{33}$ OR 2 **M2** $C_2H_4F_2$	**ACCEPT** symbols in any order correct answer without working scores 2 marks. $2CH_2F$ scores 1	2
			Total 14

(**Q05 4CH1/1C, Jan 2020**)

Q6.

Question number	Answer	Notes	Marks
(a) (i)	6/six		1
(ii)	One of the following two points methanol/it) does not contain only carbon and hydrogen OR (methanol/it) contains (an atom of) oxygen		1
(b) (i)	M1 two/ pair of electrons M2 shared between two atoms	 **ACCEPT (electrons)** attracted to the nuclei (of the two atoms in the bond) **ACCEPT** M1 (electrostatic) attraction between two nuclei M2 (and the) shared pair(s) of electrons (between them)	2
(ii)	M1 4 pairs of electrons around central carbon atom, with one pair to O and 3 pairs to H M2 rest of molecule fully correct	**ALLOW** any combination of dots and crosses M2 DEP on M1	2

Question number	Answer	Notes	Marks
(c) (i)	• Divide percentages by relative atomic masses • Divide results by smallest value to obtain ratio • Write empirical formula Example calculation M1 C: $\frac{38.7}{12}$ H: $\frac{9.7}{1}$ O: $\frac{51.6}{16}$ M2 $\frac{3.225}{(3.225)}$ $\frac{9.7}{(3.225)}$ $\frac{3.225}{(3.225)}$ **OR** 1 3 1 M3 CH_3O	0 marks if division by atomic numbers or upside-down calculation M2 subsumes M1 **ACCEPT** symbols in any order	3
(ii)	• Divide relative molecular mass by empirical formula mass • Write molecular formula Example calculation M1 $\frac{62}{12 + 3 + 16}$ **OR** $\frac{62}{31}$ (= 2) M2 $C_2H_6O_2$	 **ACCEPT** symbols in any order Correct answer without working scores 2 marks	2
			Total 11

(**Q05 4CH1/1CR, Nov 2020**)