A' Level Chemistry

Year 1

Unit 2: AOS PV=nRT

Summer Examination Revision Pack

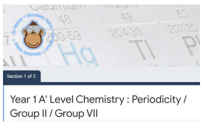
The questions in this pack should be attempted **AFTER** completing all other revision.

Grade Accelerator
Recall Definitions
Drawing Diagrams
Using Equations
Drawing Graphs

Quizlet

Quizlet Classes
Flashcard Based
Games
Tests & Quizzes
Keyword Spell Checker

Condensed Notes
Keywords & Definitions
Key Concepts
Application
Key Skills



Online Forms
Take Time to Answer
Use Paper & Calculator
Work It Out
Review Missed Marks

Use the 3 Wave Process when completing these revision packs.

1. Complete the questions without assistance
(Can't answer a question? Leave it and move on)
2. Use your notes to fill any gaps after step 1
3. Use the mark scheme to fill in any remaining gaps.

1. Having gaps after step 1 is normal, that's why we are doing revision!
2. If your notes don't help during step 2, they are not good enough!
(Change your note taking method and try to understand the problem)
3. If you don't understand why the mark scheme answer is correct, **see Andy.**

STOP If you struggle with the questions in the pack, **STOP!** and complete some more revision.

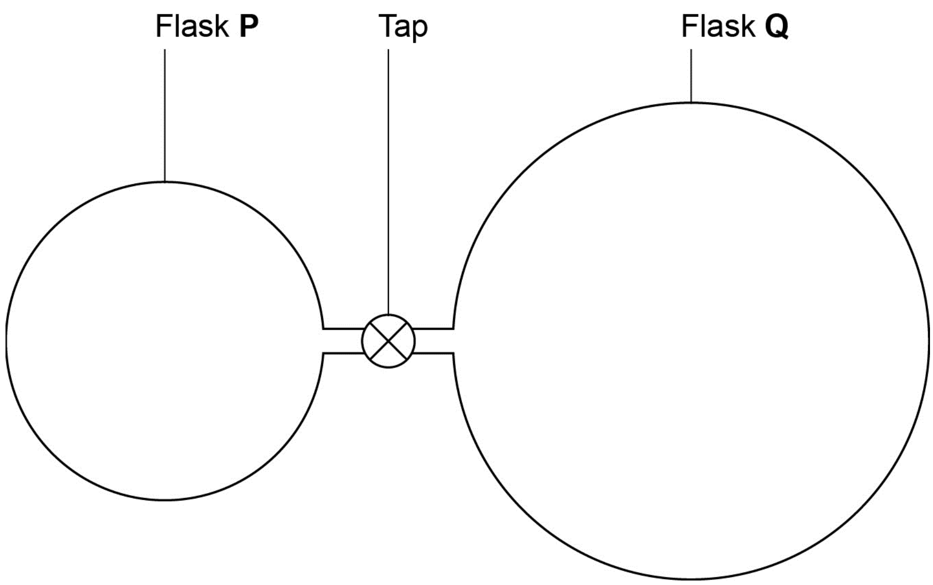
STOP If you come to a complete dead-end, **STOP!** and speak to **Andy** asap.

Do not write outside the box

5 **Figure 2** represents two glass flasks, **P** and **Q**, connected via a tap.

Flask **Q** (volume = 1.00 x 10^3 cm^3) is filled with ammonia (NH_3) at 102 kPa and 300 K. The tap is closed and there is a vacuum in flask **P**.
(Gas constant R = 8.31 J K^{-1} mol^{-1})

Figure 2



0 5 . 1 Calculate the mass of ammonia in flask **Q**.
Give your answer to the appropriate number of significant figures.

[3 marks]

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0 5 . 2 When the tap is opened, ammonia passes into flask **P**. The temperature decreases by 5 °C. The final pressure in both flasks is 75.0 kPa.
Calculate the volume, in cm^3, of flask **P**.

[3 marks]

Turn over for the next question

Question	Marking Guidance	Mark	Comments
05.1	n = PV/RT	1	If PV=nRT rearranged incorrectly then M3 only
	$\frac{102\ 000 \times (1.00 \times 10^{-3})}{8.31 \times 300} = n$ = ($4.091456077 \times 10^{-2}$)	1	
	Mass = M2 x 17 = 0.696 (g) (3 sig figs only)	1	Allow 0.695 or 0.697
05.2	If pV = nRT		Incorrect unit conversion loses M1 only; can get M2/M3 if possible volume obtained
	$\text{Total volume} = \frac{nRT}{P}$		
	$= \frac{n \times 8.31 \times 295}{75\ 000}$	1	Inserts correct numbers (inc pressure in Pa)
	= 1.34×10^{-3} m^3		
	Volume of Q in m^3 = 1.00×10^{-3}		
	Volume of bulb P = $1.34 \times 10^{-3} - 1.00 \times 10^{-3}$	1	No subtraction M1 only
	Volume of bulb P = 3.42×10^{-4} m^3		
	= 342 cm^3 (Allow 310-342 cm^3)	1	Alternative method also worth full credit (note if mol in M2 of 05.1 rounded to 0.04 this could lead to a final answer of 3.1×10^{-4} m^3 so allow range 310-342 cm^3

0 6 A student determined the relative molecular mass, M_r, of an unknown volatile liquid **Y** in an experiment as shown in **Figure 5**.
The student used a hypodermic syringe to inject a sample of liquid **Y** into a gas syringe in an oven.
At the temperature of the oven, liquid **Y** vaporised.

The student's results are shown in **Table 2**.

Figure 5

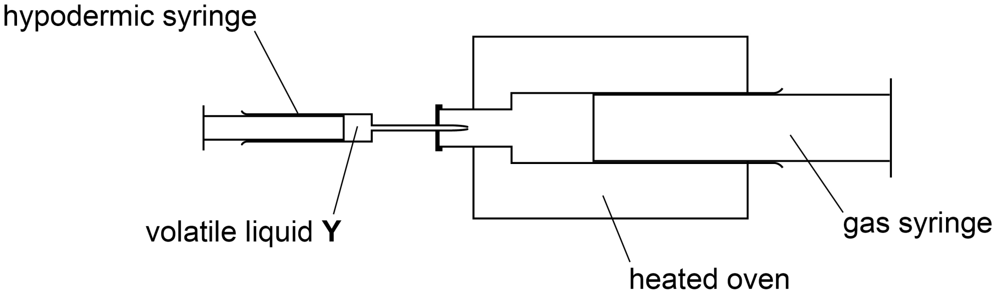

Table 2

Mass of hypodermic syringe and liquid **Y** before injection	10.91 g
Mass of hypodermic syringe and liquid **Y** after injection	10.70 g
Oven temperature	98.1 °C
Atmospheric pressure	102 kPa
Increase in volume in gas syringe after injection of **Y**	85.0 cm^3

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0 6 . 1 Define the term relative molecular mass (M_r).

Use the experimental results in **Table 2** to determine the relative molecular mass of **Y**.
The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$

[5 marks]

0 6 . 2 Some of the liquid injected did not evaporate because it dripped into the gas syringe nozzle outside the oven.

Explain how this would affect the value of the M_r of **Y** calculated from the experimental results.

[2 marks]

7

Qu	Marking Guidance		Additional Comments	Mark
6.1	$\frac{\text{The sum of (weighted) average masses of atoms in formula}}{\text{1/12 mass of an atom of } ^{12}\text{C}}$		$\frac{\text{Average mass of one molecule}}{\text{1/12 mass of an atom of } ^{12}\text{C}}$	1
	Method 1	**Method 2**		
	Mass of Y = 0.21g	Mass of Y = 0.21g	If incorrect lose M5 also, unless AE	1
	$M_r = \frac{mRT}{pV}$	$n = \frac{pV}{RT}$ and $M_r = \frac{m}{n}$	Can be implied in calculations	1
	$M_r = \frac{0.21 \times 8.31 \times 371.1}{102000 \times 85x10^{-6}}$	$n = \frac{102000 \times 85x10^{-6}}{8.31 \times 371.1}$ (= $2.81x10^{-3}$)	M4 – awarded for all 3 unit conversions If incorrect, also lose M5	1
	M_r = 74.7	M_r = 74.7	Allow 75	1
6.2	Lower volume recorded		Allow (Evaporated) mass of gas is less than the recorded mass of liquid / 0.21g (or converse)	1
	M_r would be greater (than the real M_r)		Ignore other references to mass	1

0 8 This question is about a volatile liquid, **A**.

0 8 . 1 A student does an experiment to determine the relative molecular mass (M_r) of liquid **A** using the apparatus shown in **Figure 2**.

The student injects a sample of **A** into a gas syringe in an oven.

At the temperature of the oven, liquid **A** vaporises.

Figure 2

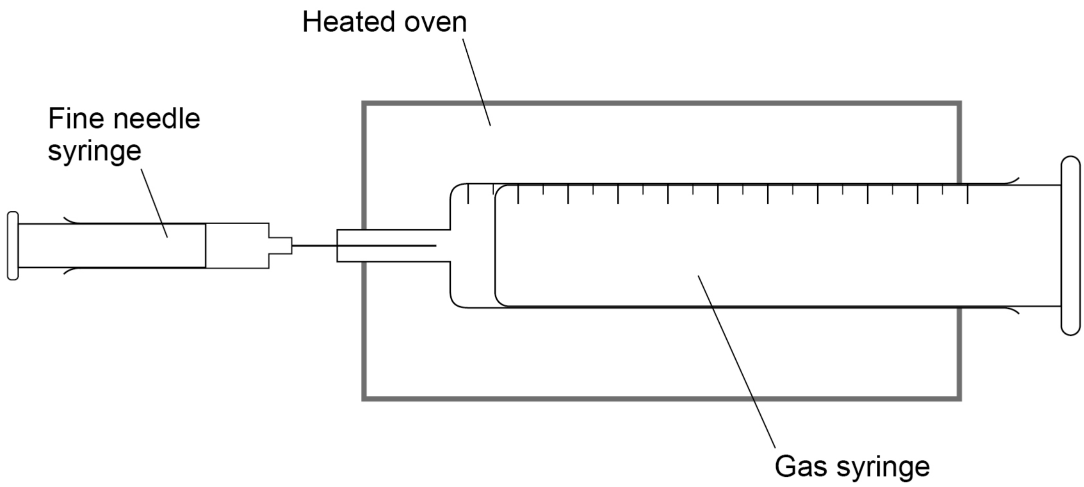

Table 3 shows the student's results.

Table 3

Mass of fine needle syringe and contents before injecting	11.295 g
Mass of fine needle syringe and contents after injecting	10.835 g
Volume reading on gas syringe before injecting	0.0 cm^3
Volume reading on gas syringe after injecting	178.0 cm^3
Pressure of gas in syringe	100 kPa
Temperature of oven	120 °C

Calculate the M_r of **A**.

Give your answer to 3 significant figures.

The gas constant, $R = 8.31\ J\ K^{-1}\ mol^{-1}$

[4 marks]

M_r ____________________

0 8 . 2 The student noticed that some of the liquid injected into the gas syringe did **not** vaporise.

Explain the effect that this has on the M_r calculated by the student.

[2 marks]

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Question 8 continues on the next page

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Table 3 is repeated here.

Table 3

Mass of fine needle syringe and contents before injecting	11.295 g
Mass of fine needle syringe and contents after injecting	10.835 g
Volume reading on gas syringe before injecting	0.0 cm^3
Volume reading on gas syringe after injecting	178.0 cm^3
Pressure of gas in syringe	100 kPa
Temperature of oven	120 °C

0 8 . 3 Each reading on the balance used to record the mass of the fine needle syringe and contents had an uncertainty of ±0.001 g

Calculate the percentage uncertainty in the mass of liquid **A** injected in this experiment.

[1 mark]

Percentage uncertainty ______________________________

7

Question	Marking guidance	Additional Comments/Guidelines	Mark
08.1	M1 $n = pV / RT$ M2 $n = \frac{100000 \times (178/1000000)}{8.31 \times (273 + 120)}$ M3 $n = 5.45 \times 10^{-3}$ mol $M_r = {}^{\text{mass}}/_{\text{mol}}$ or $0.460 / 5.45 \times 10^{-3}$ M4 M_r = <u>84.4</u> Answer must be to 3 sig.fig.	M1 for rearrangement M2 for three unit conversions M3 for calculating the amount in moles of A M4: 0.460 / M3 given to 3sf	4
08.2	Calculated *M*r value would be greater than actual A lower volume would have been recorded / mass evaporated less than mass of liquid / lower moles calculated / mass recorded higher than mass of gas / mass recorded would be too high	Mr = mass / moles so dividing by too small a value of moles gives a larger Mr than expected. M2 dependent on correct M1	1 1
08.3	% uncertainty = (uncertainty / mass added) x 100 = ((2 x 0.001) / 0.460} x 100 = 0.435%		1

0 2 An experiment was carried out to determine the relative molecular mass (M_r) of a volatile hydrocarbon **X** that is a liquid at room temperature.

A known mass of **X** was vaporised at a known temperature and pressure and the volume of the gas produced was measured in a gas syringe.

Data from this experiment are shown in **Table 1.**

Table 1

Mass of **X**	194 mg
Temperature	373 K
Pressure	102 kPa
Volume	72 cm^3

0 2 . 1 Calculate the relative molecular mass of **X.**

Show your working.

Give your answer to the appropriate number of significant figures.

The gas constant, $R = 8.31\ J\ K^{-1}\ mol^{-1}$

[5 marks]

Relative molecular mass ____________________

Question	Marking Guidance	Mark	Comments
02.1	**Stage 1** **M1** $n = \frac{PV}{RT}$ **M2** $= \frac{102 x 10^3 \ \ x \ \ 72 x 10^{-6}}{8.31 \ x \ 373}$ **M3** $= 0.0024 / 0.00237 / 0.002369 / 0.0023693$ .. **Stage 2** **M4** $M_r \ (= \frac{mass}{moles}) = \frac{0.194}{\mathbf{M3}}$ **M5** = 82 (<u>**2sf only**</u>)	1 1 1 1 1	As this is an extended response question, each separate step of correct working is required in **M1**-**M5** Correct answer with no working scores 2 marks **M1** - If expression not written out, **M1** could score from a correct expression for **M2** (even if unit conversions are not correct for **M2**) **M2** – allow an expression that gives correct value for **M3** **M3** should be <u>at least</u> 2sf (do not allow 0.0023 but do allow 0.00236) **M4** must show 0.194 or 194 x 10^{-3} in working to score **M5** must be 2sf ECF: • No ECF within either stage 1 or stage 2 (except for transcription errors) • Allow ECF from stage 1 into stage 2, i.e for **M4** and **M5** based on incorrect **M3,** (but if expression for **M4** is inverted, cannot score **M5**) • (Note that if 72 x 10^{-3} used in **M2**, then **M3** = 2.4, **M5** = 0.082) Ignore units for **M3** and **M5** Note that if T = 273 + 373 = 646, **M5** = 140 (2sf)

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0 9 . 3 Butane can be used as a replacement for CFCs in refrigerators.

During its use, the butane is repeatedly converted from liquid to gas and then back to liquid. Liquid butane expands as it turns into a gas.

- Calculate the volume, in cm^3, of 38.8 g of butane gas at 272 K and 101 kPa (the gas constant R = 8.31 J K^{-1} mol^{-1}) (M_r of butane = 58.0)
- Calculate the volume, in cm^3, of 38.8 g of liquid butane. (density of liquid butane = 0.60 g cm^{-3})
- Use your answers to calculate the factor by which butane expands in volume when it changes from a liquid to a gas.

Show your working.

[6 marks]

Volume of butane gas ______________________________ cm^3

Do not write outside the box

Volume of liquid butane ______________________________ cm^3

Expansion factor ______________________________

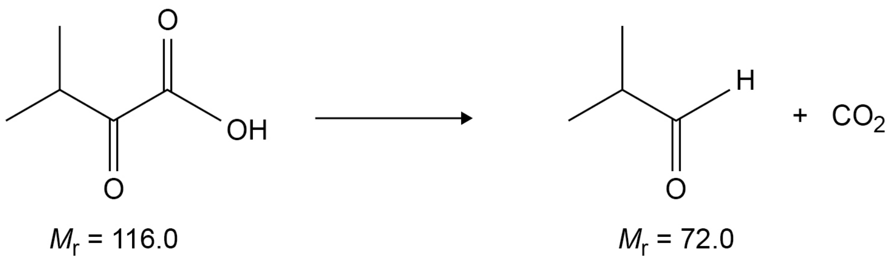
9

Turn over ►

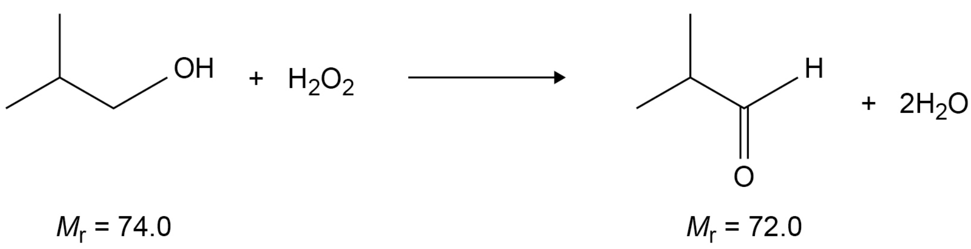
Question	Marking guidance	Additional Comments/Guidelines	Mark
09.3	Volume as a gas: **M1** moles butane = $\frac{38.8}{58.0}$ (= 0.669) **M2** $V = \frac{nRT}{P}$ **M3** $V = \frac{0.669\ x\ 8.31\ x\ 272}{101000}$ **M4** **(** = 0.0150 m^3) = 15000 (cm^3) (14971) Volume as a liquid: **M5** $V = \frac{38.8}{0.60}$ = 65 or 64.7 or 64.666… (cm^3) Expansion factor **M6** **(**$\frac{M4}{M5}$) = **(**$\frac{15000}{64.7}$) = 232 (allow 230 – 232)	Answers to **M4**, **M5** and **M6** should be 2sf or more **<u>M1-M4</u>** 15000 (cm^3) (14971) scores **M1**-**M4** **M1** may score from a value or expression within **M3** **M2** could score from an attempt at **M3** that shows attempts at values for n, R, T and P in suitable places **M4** ignore additional answers following this in other units (if incorrect it will be penalised in **M6**) Allow ECF in **M3** and **M4** based on incorrect moles of butane from **M1**; allow ECF in **M4** based on incorrect units in **M3** Allow ECF in **M3** and **M4** based on inverted expression for volume $V = \frac{P}{nRT}$; for other incorrect expressions, allow a maximum of one mark for **M3** or **M4** for correct unit conversion for P to Pa in **M3** or volume to cm^3 in **M4** **<u>M5</u>** ignore additional answers following this in other units (if incorrect it will be penalised in **M6**) 64.6 (cm^3) is outside range and does not score **M5** $64.\dot{6}$ (cm^3) (i.e. 66.6 dot scores **M5**) **<u>M6</u>** allow ECF based on values for **M4** and **M5**	1 1 1 1 1 1

0 2 A student investigates two experimental methods of making methylpropanal. The equations for these two methods are shown.

Method 1



Method 2



In each method, the student uses 1.00 g of organic starting material.

The yield of methylpropanal obtained using each method and other data are included in **Table 3**.

Table 3

	Method 1	**Method 2**
Yield of methylpropanal / mg	552	778
Percentage yield		80.0%
Percentage atom economy	62.1%	

Calculate the percentage yield for Method 1.

Calculate the percentage atom economy for Method 2.

State the importance of percentage yield and percentage atom economy when choosing the method used to make a compound.

[6 marks]

% yield ______________

Importance of percentage yield ______________

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% atom economy ______________

Importance of percentage atom economy ______________

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6

Question	Marking guidance	Additional Comments/Guidelines	Mark
03	**Percentage yield** **M1** reactant moles $= \frac{1.00}{116.0}$ (= 0.00862) **M2** product moles $= \frac{0.552}{72.0}$ (= 0.00767) **M3** % yield $= \left(\frac{0.00767}{0.00862}\ x\ 100\right)$ = 88.9(3) or 89% **M4** idea of getting as much product as possible in the reaction / idea of efficient conversion of reactants to products **Atom economy** **M5** $\left(\frac{72.0}{74.0+34.0}\ x\ 100\right) = \left(\frac{72.0}{108.0}\ x\ 100\right)$ = 66.7% **M6** idea of maximising the mass of reactants / atoms that ends up in desired product or idea of minimising the amount of by-products	Correct **M3** scores **M1-3** Numerical answers to at least 2sf Allow ECF in **M1-M3** **Alternative for M2/3** **M2** expected mass of product = 0.00862 x 72.0 (= 0.621 g) **M3** % yield $= \left(\frac{0.552}{0.621}\ x\ 100\right)$ = 88.9(3) or 89% **Alternative for M5:** $\left(\frac{72.0}{72.0+36.0}\ x\ 100\right)$	1 1 1 1 1 1

Do not write outside the box

0 6 This question is about two experiments on gases.

0 6 . 1 In the first experiment, liquid **Y** is injected into a sealed flask under vacuum.
The liquid vaporises in the flask.
Table 2 shows data for this experiment.

Table 2

Mass of **Y**	717 mg
Temperature	297 K
Volume of flask	482 cm^3
Pressure inside flask	51.0 kPa

Calculate the relative molecular mass of **Y**.

Show your working.

The gas constant, R = 8.31 J K^{-1} mol^{-1}

[5 marks]

Relative molecular mass of **Y** ____________________

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.1	***METHOD 1*** **Stage 1** **M1** $n = \frac{PV}{RT}$ **M2** converting P to 51.0 x 10^3, V to 482 x 10^{-6} **M3** $= \frac{51.0\ x\ 10^3\ \ x\ \ 482\ x\ 10^{-6}}{8.31\ \ x\ \ 297}$ $(= 0.00996)$ **Stage 2** **M4** converting mass to 0.717 **M5** $M_r \left(= \frac{mass}{moles}\right) = \frac{\mathbf{M4}}{\mathbf{M3}}$ = 72.0 (at least 2 sf) ***METHOD 2*** **M1** $n = \frac{PV}{RT}$ **M2** $M_r = \frac{mRT}{PV}$ **M3** converting P to 51.0 x 10^3, V to 482 x 10^{-6} **M4** converting mass to 0.717 **M5** $M_r = \left(\frac{0.717\ \ x\ \ 8.31\ \ x\ \ 297}{51.0\ x\ 10^3\ \ x\ \ 482\ x\ 10^{-6}}\right)$ = 72.0 (at least 2 sf)	***Both methods:*** 72.0 can be achieved with incorrect working and may not score because individual steps need to be assessed as correct 72.0 with no working scores no marks If expression not written out, **M1** could score from a substituted correct expression later on (even if any unit conversions are incorrect) ***METHOD 1*** • ECF from **M2** to **M3** • ECF from **M3** to **M4** • ECF from **M4** to **M5** • Ignore units for **M3** ***METHOD 2*** • ECF from **M3** to **M4** • ECF from **M2** to **M4** • ECF from **M4** to **M5**	1 1 1 1 1

Do not write outside the box

0 4 This question is about gas volumes.

0 4 . 1 TNT ($C_7H_5N_3O_6$) is an explosive because it can decompose very quickly and exothermically to form a large volume of gas. An equation for this decomposition is

$$2\,C_7H_5N_3O_6(s) \rightarrow 3\,N_2(g) + 5\,H_2(g) + 12\,CO(g) + 2\,C(s)$$

Calculate the volume of gas, in m^3, measured at 1250 °C and 101 000 Pa, produced by the decomposition of 1.00 kg of TNT (M_r = 227.0).

The gas constant, R = 8.31 J mol^{-1} K^{-1}

[5 marks]

Volume of gas ______________________________ m^3

Do not write outside the box

0 4 . 2 Alkenes have the general formula C_nH_{2n}

When alkenes undergo complete combustion, 1.0 mol of C_nH_{2n} reacts with $\frac{3n}{2}$ mol of oxygen.

Calculate the volume of oxygen needed for the complete combustion of 200 cm^3 of but-1-ene.

The volumes of all gases are measured at the same temperature and pressure.

[1 mark]

Volume of oxygen ______________________ cm^3

0 4 . 3 Alkanes have the general formula C_nH_{2n+2}

Alkanes undergo complete combustion in a plentiful supply of oxygen.

$$C_nH_{2n+2} + x\,O_2 \rightarrow n\,CO_2 + (n+1)\,H_2O$$

Determine x in terms of n

[1 mark]

x ______________________

7

Turn over for the next question

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.1	**M1** amount of TNT = $\frac{1000}{227.0}$ (= 4.41 mol) **M2** amount of gases formed = 10 x **M1** (= 44.1 mol) **M3** $V = \frac{nRT}{P}$ **M4** converting T to 1523 (K) (or 273 + 1250) **M5** $V = \frac{\textbf{M2} \times 8.31 \times 1523}{101000}$ = 5.52 (m^3) range 5.5(1) to 5.53 (m^3)	Final answer should be at least 2sf Correct final answer scores 5 marks Allow ECF from **M1** to **M2**, **M2** to **M5**, **M4** to **M5** and **M3** to **M5** 0.552 (m^3) for using 4.41 mol in **M5** scores 4 marks (loses **M2**) 4.54 (m^3) for using 1250 K scores 4 marks (loses **M4**); 3.54 (m^3) for using (1250 – 273) K scores 4 marks (loses **M4**); 0.18 (m^3) for inverted expression scores 4 marks (loses **M3** or **M5**) **M3** can score from a substituted expression	1 1 1 1 1 (1 x AO1, 4 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.2	1200 (cm^3)	200 x $\frac{3n}{2}$ where n = 4 200 x $\frac{12}{2}$	1 (AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.3	$\frac{3n+1}{2}$	1.5n + 0.5 allow other correct expressions (e.g. $n + \frac{(n+1)}{2}$)	1 (AO1)