1 Hydrogen peroxide, H_2O_2, is used in some spacecraft to provide oxygen.

(a) Hydrogen peroxide can be made from hydrogen and oxygen.

$$H_2 + O_2 \rightarrow H_2O_2$$

(i) This reaction has a 100% atom economy.

Explain how you can tell from the equation.

.....

..... **[1]**

(ii) Industrial chemical processes should have as high an atom economy as possible.

Explain **two** reasons why.

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..... **[2]**

(b) Oskar uses 100 g of hydrogen.

(i) Show that the predicted yield of hydrogen peroxide is 1700 g.

$$H_2 + O_2 \rightarrow H_2O_2$$

The relative formula mass, M_r, of H_2 = 2, of O_2 = 32 and of H_2O_2 = 34.

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..... **[2]**

(ii) Oskar's actual yield of hydrogen peroxide is 1530 g.

He predicts he should make 1700 g of hydrogen peroxide.

Calculate Oskar's percentage yield of hydrogen peroxide.

percentage yield = ...% **[2]**

(c) Hydrogen peroxide can also be made from barium peroxide.

barium peroxide + sulfuric acid → hydrogen peroxide + barium sulfate

BaO_2 + H_2SO_4 → H_2O_2 + $BaSO_4$

The table shows the relative formula masses, M_r, of the substances in the symbol equation.

Substance	Relative formula mass, M_r
BaO_2	169
H_2SO_4	98
H_2O_2	34
$BaSO_4$	233

Barium sulfate is a waste product in this reaction.

Calculate the atom economy for this reaction.

atom economy = ...% **[2]**

2 Ethanoic acid, $C_2H_4O_2$, can be made by several different processes.

Three of these are process **R**, process **S** and process **T**.

(a) In process **R**, methanol reacts with carbon monoxide.

$$CH_4O + CO \rightarrow C_2H_4O_2$$

Process **R** has 100% atom economy.

Explain how you can tell this from the symbol equation.

.....

.....

..... **[1]**

(b) In process **S**, sodium ethanoate, $NaC_2H_3O_2$, reacts with sulfuric acid.

$$2NaC_2H_3O_2 + H_2SO_4 \rightarrow Na_2SO_4 + 2C_2H_4O_2$$

Look at the table of relative formula masses, M_r.

Substance	**Relative formula masses, M_r**
$NaC_2H_3O_2$	82
H_2SO_4	98
Na_2SO_4	142
$C_2H_4O_2$	60

(i) A mass of 8.2 g of sodium ethanoate reacts with excess sulfuric acid.

What mass of ethanoic acid, $C_2H_4O_2$, can be made?

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mass of ethanoic acid = ... g **[2]**

(ii) Calculate the **atom economy** for process **S**.

Sodium sulfate, Na_2SO_4, is a waste product.

.....

.....

.....

atom economy = ... % **[2]**

(c) In process **T**, hydrocarbons are oxidised to make ethanoic acid.

Mike predicts that 5.2 tonnes of ethanoic acid should be made.

The factory actually makes 2.4 tonnes of ethanoic acid.

(i) Calculate the percentage yield of ethanoic acid.

Write your answer to **two** significant figures.

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percentage yield = ... % **[2]**

(ii) Describe one disadvantage of having a percentage yield of this value.

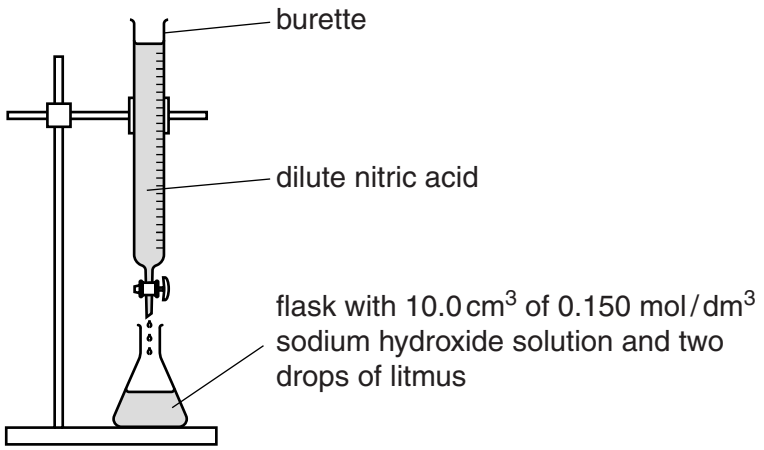
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..... **[1]**

[Total: 8]

3 Cristina titrates dilute nitric acid with sodium hydroxide solution.

Look at the diagram of her apparatus.



Cristina slowly adds dilute nitric acid into the flask until the end point is reached.

(a) Cristina uses litmus to tell her when the end point is reached.

She **should not** use universal indicator.

Explain why.

.....

..... **[1]**

(b) Cristina does three more titrations.

Look at her results table.

Titration number	**1**	**2**		
Final burette reading in cm^3	26.5	49.2	26.4	40.3
Initial burette reading in cm^3	0.0	24.1	1.2	15.0
Titre (volume of acid added) in cm^3	26.5	25.1	25.2	25.3

(i) Cristina calculates the mean titre to be 25.2 cm^3.

Explain why this is the **best** mean value from these results.

.....

.....

..... **[2]**

(ii) Cristina uses 10.0 cm^3 of sodium hydroxide solution.

The concentration of the sodium hydroxide solution is 0.150 mol/dm^3.

Calculate the number of moles of sodium hydroxide in 10.0 cm^3 of this solution.

.....

.....

number of moles = ... **[1]**

(iii) Look at the equation for the reaction between nitric acid and sodium hydroxide.

$$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$$

Use the information from parts **(i)** and **(ii)** to calculate the concentration of the nitric acid.

Give your answer to **three** significant figures.

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concentration of nitric acid = ... mol/dm^3 **[2]**

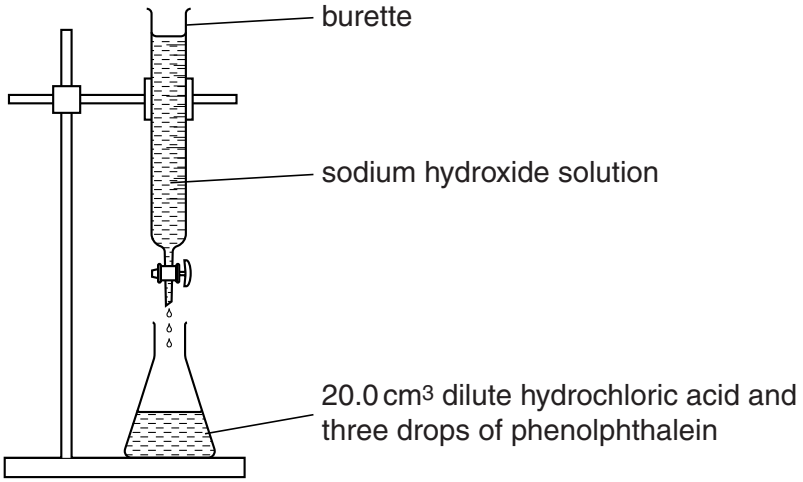
[Total: 6]

4 This question is about acid-base titrations.

Brian neutralises dilute hydrochloric acid with sodium hydroxide solution.

He wants to find out the concentration of the sodium hydroxide solution.

Look at the apparatus.



Brian adds sodium hydroxide solution slowly until the phenolphthalein changes colour.

He does the titration four times.

Look at Brian's results.

Titration number	**1**	**2**	**3**	**4**
Volume of sodium hydroxide added in cm^3	25.9	24.9	25.1	25.0

Brian calculates the mean volume of sodium hydroxide solution to be 25.0 cm^3.

(a) Titration **1** was not included in the calculation of the mean volume of sodium hydroxide added.

Suggest why.

..... **[1]**

(b) Look at the equation for the reaction.

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

The mean volume of sodium hydroxide solution used is 25.0 cm^3.

Brian uses 20.0 cm^3 of hydrochloric acid.

The concentration of the hydrochloric acid is 0.100 mol/dm^3.

Calculate the concentration of the sodium hydroxide in mol/dm^3.

answer ..... mol/dm^3 **[3]**

(c) Phenolphthalein is a single indicator.

Universal indicator is a mixed indicator.

Explain why Brian used phenolphthalein rather than universal indicator.

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.....

..... **[2]**

[Total: 6]

5 Look at the table.

It shows information about the contents of some foods on food labels.

It also shows the Guideline Daily Amounts (GDA) for an adult.

Food contents	**Small pizza**	**Chicken curry**	**Fish in cheese sauce**	**GDA for an adult**
Energy in calories	396	384	200	2000
Protein in g	16.9	41.4	22.8	45
Carbohydrate in g	51.3	11.0	2.9	230
Fat in g	13.7	19.2	10.8	70
Sodium in g	0.7	0.9	0.4	2.3

(a) Look at the information for the chicken curry.

What percentage of the GDA for **fat** is in the chicken curry?

answer ..... % **[2]**

(b) The chicken curry contains 1.17 g of salt.

Salt is sodium chloride, NaC*l*.

(i) Calculate the mass of sodium in 1.17 g of salt.

Give your answer correct to **2 significant figures**.

The relative atomic mass, A_r, of Na is 23 and of C*l* is 35.5.

answer ..... g **[1]**

(ii) Why is the value that you calculated in part **(i)** less than the value in the table?

.....

..... **[1]**

[Total: 4]

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6 Space probes have been sent to Mars to analyse the soil.

One compound analysed has the formula $Ca(ClO_4)_2$.

(a) Calculate the molar mass of $Ca(ClO_4)_2$.

The relative atomic mass, A_r, of O = 16, of Cl = 35.5 and of Ca = 40.

molar mass ..... g/mol **[1]**

(b) A compound with the formula K_2FeO_4 has also been discovered on Mars.

A sample of K_2FeO_4 is analysed.

The 1.00 g sample contains 0.39 g of potassium and 0.28 g of iron.

Calculate the percentage by mass of oxygen in this sample of K_2FeO_4.

percentage by mass = ... % **[2]**

(c) Another compound found on Mars has the molecular formula C_4H_{10}.

What is the **empirical** formula for this compound?

..... **[1]**

(d) Another compound found on Mars contains iron and oxygen.

The compound contains 70% by mass of iron and 30% by mass of oxygen.

Calculate the empirical formula of this compound.

The relative atomic mass, A_r, of O = 16 and of Fe = 56.

empirical formula is ..... **[3]**

7 This question is about acids.

Nitric acid, HNO_3, is a strong acid and propanoic acid, C_2H_5COOH, is a weak acid.

David investigates the reaction of both of these acids with calcium carbonate.

David does two experiments

- the first with nitric acid
- the second with propanoic acid.

Each time he puts 50 cm^3 of 2.0 mol/dm^3 acid into a conical flask.

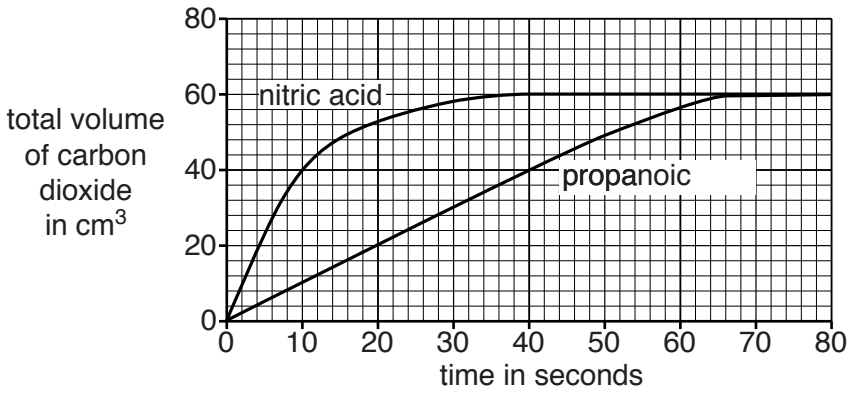
He then adds the same mass of calcium carbonate to each acid.

David measures the total volume of carbon dioxide made every 10 seconds.

(a) Draw a labelled diagram of the apparatus David can use in these experiments.

[2]

(b) Look at the graph of David's results.



The two lines are different shapes because the strength of each acid is different.

Write about the difference between a strong and a weak acid and explain why the two lines are different.

The quality of written communication will be assessed in your answer to this question.

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..... **[6]**

(c) Look at the balanced symbol equation for the reaction of calcium carbonate with nitric acid.

$$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + CO_2 + H_2O$$

(i) David's experiment with nitric acid makes 60 cm^3 of carbon dioxide at room temperature and pressure.

How many moles of carbon dioxide are made at the end of the reaction?

One mole of carbon dioxide has a volume of 24 000 cm^3 at room temperature and pressure.

moles of carbon dioxide = ... **[1]**

(ii) Calculate the mass of calcium carbonate needed to make this amount of carbon dioxide.

The relative formula mass, M_r, of calcium carbonate, $CaCO_3$, is 100.

mass of calcium carbonate = …….. g **[1]**

8 In a closed system a reversible reaction will form an equilibrium mixture.

(a) Which of the following statements are true for a reversible reaction at **equilibrium**?

Tick (✓) the **two** correct answers.

The rate of the forward reaction is faster than the rate of the backward reaction.	☐
The position of equilibrium will not change if more product is added.	☐
The concentration of the reactants does not change.	☐
The rate of the forward reaction is the same as the rate of the backward reaction.	☐
The concentration of the reactants is the same as the concentration of the products.	☐
The position of equilibrium moves to the left when product is removed from the equilibrium.	☐

[2]

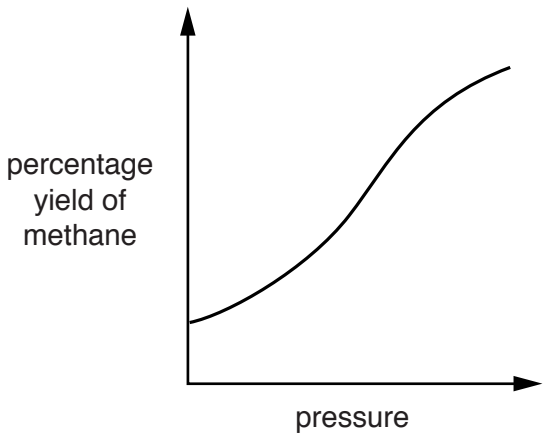
(b) Methane is a fuel that can be made by the reaction between carbon dioxide and hydrogen.

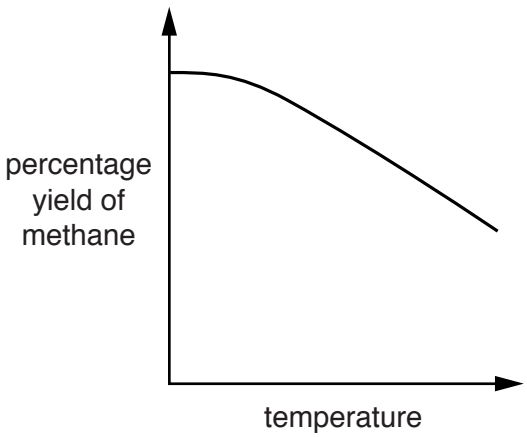
$$CO_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2O(g)$$

Paul predicts that

- the reaction is exothermic
- there are more moles of gas on the right-hand side of the equation.

Look at the two graphs.





Do the graphs support Paul's predictions?

Explain your answer.

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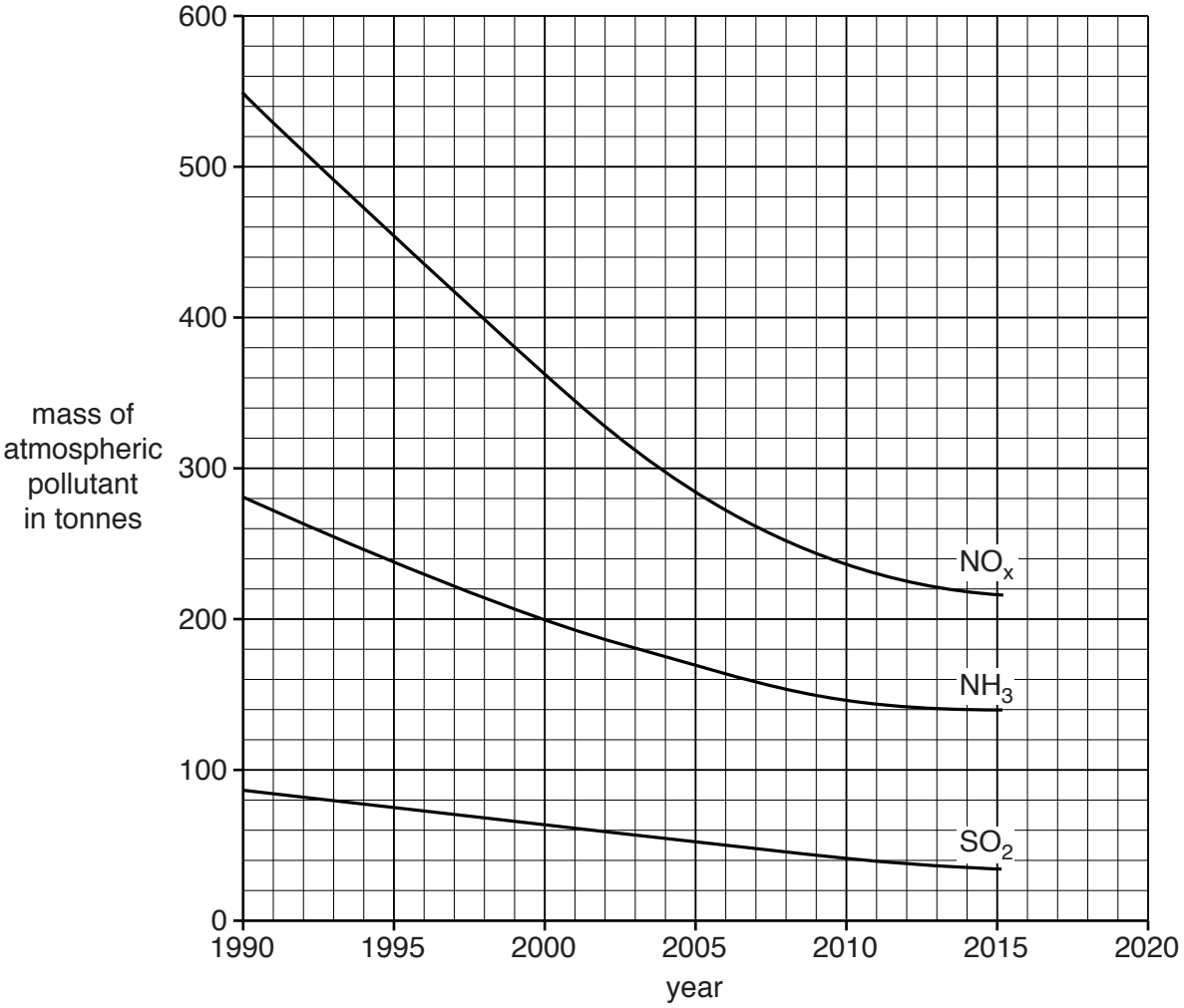
..... **[2]**

9 This question is about air pollution.

Three atmospheric pollutants are ammonia, NH_3, oxides of nitrogen, NO_x, and sulfur dioxide, SO_2.

(a) Look at the graph.

It shows how the masses of atmospheric pollutants have changed in a city since 1990.



Which atmospheric pollutant showed the **greatest** change in mass between 1990 and 2000?

Explain your answer.

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..... **[2]**

(b) The table shows information about atmospheric pollutants in some countries of the European Union.

Country	Population in millions	Mass of pollutant made in kilotonnes		
		NO_x	SO_2	NH_3
Estonia	1.3	38	83	10
Germany	80	1323	449	548
Poland	39	867	974	271
Slovakia	5.4	89	69	24
Sweden	9.6	161	34	52
United Kingdom	64	1106	406	284
Whole of European Union	508	9200	4600	3600

(i) What percentage of the total mass of NH_3 made by the European Union comes from Sweden?

percentage = ... % **[2]**

(ii) The population of Sweden is 1.9% of the population of the European Union.

Compare this percentage with your answer in part **(i)**.

What conclusion can you make from these results?

.....

.....

..... **[1]**

(iii) Across the whole of the European Union an average of 9.1 kilotonnes of SO_2 is made for every million people.

In Poland how many kilotonnes of SO_2 are made for every million people?

Give your answer to **two significant figures**.

answer = ... kilotonnes **[2]**

(iv) What conclusion can you make from your answer?

.....

..... **[1]**

(v) Ann concludes that the amount of atmospheric pollutant made by a country is linked only to its population.

Nick thinks there are **other** factors involved as well.

Evaluate the evidence in the table in terms of both of these conclusions.

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..... **[2]**