Name	Date started	Target end date

GCE AS / A LEVEL — CHEMISTRY UNIT 1 QUESTION PACK

1091-01 (Legacy CH1) · New spec Unit 1 Topic 7 · AS unit, first sat 2016, 80 marks, 1h 30min paper

REVISE
.wales

CHEMISTRY — UNIT 1 · ACID&NDASH;BASE TITRATIONS

Topics 1.3 + 1.7 — Titration calculations, strong & weak acids, and acid-base practical

Carrying out acid-base titrations with concordant titres, calculating concentrations and unknown molar masses, and applying Brønsted-Lowry concepts to strong and weak acids.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~2 h 37 min

Derived from the legacy CH1 paper's pace of ~1.1 min/mark, padded for long-prose answers (98 marks over 9 questions).

You are advised to ***not*** *attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC CH1 papers (2008 modular spec, Jan 2009 – Jun 2016) that maps onto the new-spec AS Unit 1 Topic 1.3 / 1.7.

Questions are ordered by source paper date.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working — quality of written communication will affect marks. A calculator is allowed. You may need the WJEC Periodic Table / Data Booklet.

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Q	Source	Max	Mark
1	Jun 09 Q9	14	
2	Jan 10 Q10	17	
3	Jun 10 Q11	16	
4	Jan 12 Q4	2	
5	Jun 12 Q10	12	
6	Jan 13 Q11	11	
7	Jun 13 Q6	2	
8	Jun 13 Q10	10	
9	Jun 16 Q8	14	
	Total	**98**	

Acid–Base Titrations — what the new spec asks

WJEC GCE AS / A Level Chemistry (from 2015) · Unit 1: The Language of Chemistry, Structure of Matter & Simple Reactions · Topic 1.3 / 1.7.

Acid-base theory

- Brønsted-Lowry acid: proton donor.
- Brønsted-Lowry base: proton acceptor.
- Conjugate pairs differ by one H^+.
- Strong acid/base: fully dissociated; weak: partial.

Titration practical

- Pipette known V of one reagent into conical flask.
- Burette filled with titrant; add slowly with swirling.
- Indicator changes colour at end-point.
- Concordant titres within 0.10 cm^3; mean of 2-3.

Indicators

- Strong acid + strong base: any indicator (e.g. methyl orange, phenolphthalein).
- Strong acid + weak base: methyl orange.
- Weak acid + strong base: phenolphthalein.

Calculations

- Moles in known reagent = c × V (in dm^3).
- Use balanced equation to find moles of unknown.
- $c_{unknown} = n / V$ or $M_{unknown} = m / n$.
- Significant figures: report to 3 s.f., matching data.

Crib sheet »

Acid–Base Titrations in one page

Quick-reference notes — revisit before each question.

Brønsted-Lowry

Acid: proton donor (HCl).

Base: proton acceptor (NH_3).

Conjugate pair: HA / A^-.

Strong vs weak

Strong acid: fully dissociated (HCl, HNO_3, H_2SO_4).

Weak acid: partial (CH_3COOH).

pH(strong) is calculable from c.

Apparatus

Pipette — accurate fixed volume.

Burette — variable, read to 0.05 cm^3.

Conical flask, white tile under.

Method essentials

Rinse pipette / burette with solution they will hold.

Take rough titre first.

Run in dropwise near end-point.

Concordant: within 0.10 cm^3.

Calc step-by-step

1. Mean titre.
2. n (known) = c × V.
3. n (unknown) via mole ratio.
4. Compute c, M or m as required.

Indicator choice

Strong & strong: any.

Strong + weak base: methyl orange.

Weak + strong base: phenolphthalein.

Never universal indicator (gradual change).

Questions begin overleaf.

9. Elinor is given a mixture containing sodium carbonate and she carries out a two-part experiment to determine the percentage of sodium carbonate in the mixture.

In part 1, she accurately weighs 2.05 g of the mixture, transfers all of it to an appropriate container, adds 100 cm^3 of distilled water to ensure that it all dissolves and accurately makes up the solution to 250 cm^3 with distilled water.

In part 2, she pipettes 25.0 cm^3 of the solution into a container, adds 3 drops of an appropriate indicator and titrates this solution with hydrochloric acid of concentration 0.100 mol dm^{-3}. She repeats this procedure three times and obtains the following results.

Titration	1	2	3	4
Final reading (cm^3)	23.50	24.10	24.10	23.40
Initial reading (cm^3)	0.40	0.15	0.90	0.25
Titre (cm^3)				

(a) Name a suitable container to make up the solution that could be used in part 1. [1]

....

(b) Complete the table to show the values of the titres. [1]

(c) Identify clearly any anomalous results and calculate a mean value. [1]

....

....

(d) The equation for the reaction between sodium carbonate and hydrochloric acid is given below.

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

(i) Use your answer to part (c) to calculate the number of moles of HCl used in the titration. [1]

....

....

(ii) Deduce the number of moles of Na_2CO_3 in 25.0 cm^3 of the solution. [1]

....

(iii) Calculate the total number of moles of Na_2CO_3 in the original 250 cm^3 solution. [1]

(iv) Calculate the mass of Na_2CO_3 in the original solution. [1]

(v) Calculate the percentage of Na_2CO_3 in the mixture. [1]

(e) Elinor's percentage for sodium carbonate was slightly lower than the actual value. When asked why, she stated 'I did not add the acid drop by drop at the end and so overshot the end-point'.

State two other common sources of error in such experiments and explain why Elinor's statement cannot be correct.
(Assume that all the equipment is clean and all chemicals are pure.) [4]

QWC [2]

Total [14]

Section B Total [70]

10. Ammonia, NH_3, and hydrochloric acid, HCl, undergo an acid-base reaction in aqueous solution.

$$NH_3(aq) + HCl(aq) \longrightarrow NH_4^+(aq) + Cl^-(aq)$$

(a) Explain why this is an acid-base reaction, clearly identifying **both** the acidic and basic reactants. [2]

(b) A 25 cm^3 sample taken from a stock aqueous solution of ammonia was mixed with 25 cm^3 of a solution containing excess hydrochloric acid. The temperature of the mixture rose by 0.7 °C.

(i) Given that the enthalpy change for the reaction, ΔH, is –53.4 kJ mol^{-1}, use the equation below to calculate n, the number of moles of ammonia, NH_3, which has reacted.

$$\Delta H = \frac{-vc\Delta T}{n}$$

where v is the **total** volume of solution (cm^3)
c is the specific heat capacity (4.2 J cm^{-3} $°C^{-1}$)
ΔT is the temperature change (°C)
n is the number of moles of ammonia reacted [3]

(ii) Calculate the concentration (mol dm^{-3}) of the original ammonia stock solution. [1]

(c) The concentration of the same stock aqueous solution of ammonia used in part *(b)* was also determined by an acid-base titration. Three separate 25.00 cm^3 samples of the ammonia solution were titrated against hydrochloric acid of concentration 0.1000 mol dm^{-3} from a burette, using an appropriate indicator.

The three titre volumes were 31.25 cm^3, 31.25 cm^3 and 31.20 cm^3 respectively.

(i) Calculate the mean titre volume and use this to find the concentration (mol dm^{-3}) of the ammonia solution. [2]

....

....

....

(ii) Compare the concentration values for the stock ammonia solution obtained by the two experimental methods, *(b)*(ii) and *(c)*(i). State which experiment will give the more precise value, giving **two** reasons for your choice. [3]

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Turn over.

(d) During World War II, ammonia was used as a fuel for running buses in Belgium. With the current problems associated with fossil fuels, interest in the use of ammonia as a fuel is being revived.
Some relevant standard enthalpy changes of formation, $\Delta H_f^{\ominus}$, are given in the table below.

Species	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CH_4(g)$	–74.8
$CO_2(g)$	–393.5
$H_2O(g)$	–241.8
$N_2(g)$	0
$NH_3(g)$	–46.1
$O_2(g)$	0

(i) Explain why $N_2(g)$ and $O_2(g)$ each have a value of zero for their standard enthalpy change of formation, $\Delta H_f^{\ominus}$. [1]

....

....

(ii) Use the $\Delta H_f^{\ominus}$ values given to calculate:

I the standard enthalpy change, $\Delta H^{\ominus}$, for the combustion of ammonia;

$$4NH_3(g) + 3O_2(g) \longrightarrow 2N_2(g) + 6H_2O(g)$$ [2]

....

....

....

II the standard enthalpy change, $\Delta H^{\ominus}$, for the combustion of methane (as an example of a fossil fuel).

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$$ [2]

....

....

....

(iii) State **one** advantage and **one** disadvantage of using ammonia as a fuel compared to using methane. [2]

Advantage of using ammonia ....

....

Disadvantage of using ammonia ....

....

Total [18]

Section B Total [70]

11. Potash is a common name for potassium carbonate. Originally, potash was obtained by adding water to the ash produced from the burning of wood, filtering and evaporating the filtrate.

(a) Meirion was asked to find the percentage of potash that could be obtained from some wood ash. He added water to a known mass of wood ash, stirred the mixture and then filtered the product. The filtrate was then made up to a volume of 250 cm^3.

(i) State why the mixture was stirred. [1]

....

....

(ii) Describe, giving full practical details, how the volume was made up to **exactly** 250 cm^3. [4]

....

....

....

....

....

....

(iii) The filtrate was an alkaline solution of potassium carbonate. This was titrated against a standard hydrochloric acid solution to find the concentration of the potassium carbonate.

$$K_2CO_3 + 2HCl \longrightarrow 2KCl + CO_2 + H_2O$$

Methyl orange was used as an indicator; this turns from yellow in the potassium carbonate solution to pink when the potassium carbonate is neutralised by the hydrochloric acid. The following results were obtained using 25.00 cm^3 samples of the potassium carbonate solution.

Burette finish / cm^3	24.80	26.20	26.55
Burette start / cm^3	0.00	1.60	2.00

I Calculate the mean volume of hydrochloric acid added, using all three sets of results. [1]

....

....

II Describe the practical steps used to obtain a titration value. You should start by measuring 25.00 cm^3 of the potassium carbonate solution from the 250 cm^3 stock solution, with the acid already in the burette. [5]

QWC [1]

(b) In another experiment Penny obtained white crystals of potassium carbonate, K_2CO_3, from the wood ash.

(i) Show that the percentage by mass of potassium in K_2CO_3 is 56.6. [2]

(ii) Some of Penny's crystals were analysed for potassium by flame emission spectroscopy. The results showed that the percentage of potassium present was 44.9%.
Penny suggested that the crystals of potassium carbonate might be a hydrate, $K_2CO_3.2H_2O$.

Explain why the percentage of potassium in the hydrate is lower than the value stated in (i). [1]

(c) Potassium compounds are usually obtained from mineral deposits of potassium chloride rather than from wood ash.

Suggest **one** environmental disadvantage of using wood ash to obtain potassium compounds. [1]

Total [16]

Section B Total [70]

4. In an experiment, Aled titrated 25.00 cm^3 of potassium hydroxide solution with hydrochloric acid, and obtained the following results.

	1	2	3	4
Initial burette reading / cm^3	0.10	0.25	1.20	21.30
Final burette reading / cm^3	20.85	20.45	21.30	41.60
Volume used / cm^3				

(a) Complete the table to show the volume used in each titration. [1]

(b) Calculate the mean volume that Aled should use for his further calculations. [1]

....

....

.... cm^3

10. Berian was asked to find the identity of a Group 1 metal hydroxide by titration.

He was told to use the following method.

- Fill a burette with hydrochloric acid solution.
- Accurately weigh about 1.14 g of the metal hydroxide.
- Dissolve all the metal hydroxide in water, transfer the solution to a volumetric flask then add more water to make exactly 250 cm^3 of solution.
- Accurately transfer 25.0 cm^3 of this solution into a conical flask.
- Add 2-3 drops of a suitable indicator to this solution.
- Carry out a rough titration of this solution with the hydrochloric acid.
- Accurately repeat the titration several times and calculate a mean titre.

Berian's results are shown below:

Mass of metal hydroxide = 1.14 g

Concentration of acid solution = 0.730 g HCl in 100 cm^3 of water

Mean titre = 23.80 cm^3

(a) Give a reason why Berian does not simply add 1.14 g of metal hydroxide to 250 cm^3 of water. [1]

....

....

(b) Name a suitable piece of apparatus for transferring 25.0 cm^3 of the metal hydroxide solution to a conical flask. [1]

....

(c) State why he adds an indicator to this solution. [1]

....

(d) Suggest why Berian was told to carry out a rough titration first. [1]

....

....

(e) Explain why he carried out several titrations and calculated a mean value. [1]

....

....

(f) The equation for the reaction between the metal hydroxide and hydrochloric acid is given below. M represents the symbol of the Group 1 metal.

$$\mathrm{MOH} + \mathrm{HCl} \longrightarrow \mathrm{MCl} + \mathrm{H_2O}$$

(i) Calculate the concentration, in mol $\mathrm{dm^{-3}}$, of the HCl in the burette. [2]

....

....

(ii) Calculate the number of moles of HCl used in the titration. [1]

....

....

(iii) Deduce the number of moles of MOH in 25.0 $\mathrm{cm^3}$ of the solution. [1]

....

(iv) Calculate the total number of moles of MOH in the original solution. [1]

....

....

(v) Calculate the relative molecular mass of MOH. [1]

....

....

(vi) Deduce the Group 1 metal in the hydroxide. [1]

....

Total [12]

Section B Total [70]

11. *(a)* An aqueous solution of methanoic acid can be used to dissolve 'lime scale' in kettles. The concentration of a methanoic acid solution used for this purpose can be found by a titration using sodium hydroxide solution. For this purpose a 25.0 cm^3 sample of aqueous methanoic acid was diluted to 250 cm^3.

(i) State the name of the piece of apparatus used to

I measure out 25.0 cm^3 of aqueous methanoic acid, [1]

....

II contain exactly 250 cm^3 of the diluted solution. [1]

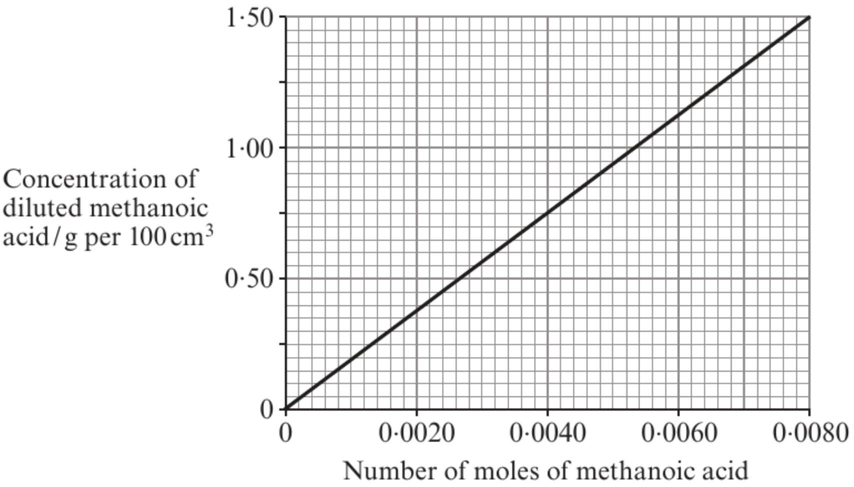
....

(ii) A 25.0 cm^3 sample of the diluted methanoic acid was titrated with sodium hydroxide solution of concentration 0.200 mol dm^{-3}. A volume of 32.00 cm^3 was needed to react with all the methanoic acid present.

Calculate the number of moles of sodium hydroxide used. [1]

Moles of sodium hydroxide = ... mol

(iii) Methanoic acid and sodium hydroxide react together in a 1:1 molar ratio.
Use the graph below and your result from (ii) to find the concentration of methanoic acid present in the diluted solution in g per 100 cm^3 of solution. [1]



Concentration = ... g per 100 cm^3

(iv) State the concentration of the original methanoic acid in g per 100 cm^3 solution. [1]

Original concentration = ... g per 100 cm^3

(b) Methanoic acid, HCOOH, can be reduced to methanol, CH_3OH, in a gas phase reaction, by using hydrogen in the presence of a solid ruthenium metal catalyst.

(i) Ruthenium is acting as a heterogeneous catalyst.
State the meaning of the word *heterogeneous*. [1]

....

....

(ii) The equation for the reduction of methanoic acid is shown below.

Use the table of bond enthalpies to find the enthalpy change for this reaction. [3]

Bond	Average bond enthalpy / $kJ\,mol^{-1}$
C—H	412
C—O	360
C=O	743
H—H	436
O—H	463

Enthalpy change = ... $kJ\,mol^{-1}$

(c) The relative molecular mass of methanoic acid is 46.02.

State why this quantity does not have units. [1]

....

....

(d) Methanoic acid reacts with propan-1-ol to give 1-propyl methanoate.

$$\mathrm{HCOOH} + \mathrm{CH_3CH_2CH_2OH} \rightleftharpoons \underset{\text{1-propyl methanoate}}{\mathrm{HCOOCH_2CH_2CH_3}} + \mathrm{H_2O}$$

(i) This reaction eventually reaches dynamic equilibrium.
State what is meant by *dynamic equilibrium*. [1]

....

....

....

(ii) Give the empirical formula of 1-propyl methanoate. [1]

Empirical formula ....

Total [12]

Section B Total [70]

END OF PAPER

5. Name an element that has a half-filled set of *p*-orbitals. [1]

....

6. Vinegar is a dilute solution of a weak acid.

(a) State what is meant by an *acid*. [1]

....

....

(b) Suggest a pH value for vinegar. [1]

....

Section A Total [10]

Turn over.

10. Hydrated sodium carbonate, $Na_2CO_3.xH_2O$, is a crystalline solid that can be used to prepare a standard solution for titration.

(a) The relative molecular mass of this hydrated sodium carbonate is 286.2. Calculate the value of x in this formula. [1]

x = ...

(b) Emily wants to prepare 250 cm^3 of a solution of sodium carbonate of concentration 0.200 mol dm^{-3} using this hydrated sodium carbonate.

(i) Calculate the mass of hydrated sodium carbonate needed to prepare this solution. [2]

Mass of hydrated sodium carbonate = ... g

(ii) Emily proposes to make the solution by the following method.

- Weigh the required mass of hydrated sodium carbonate.
- Place the hydrated sodium carbonate in a beaker and add 250 cm^3 of distilled water.
- Stir the mixture until all the sodium carbonate dissolves.
- Transfer the solution to the volumetric flask and shake.

Her teacher said that the method was not correct. Suggest **two** changes that Emily should make to her method. [2]

1. ....

....

....

2. ....

....

....

(c) Emily then prepared 250 cm^3 of sodium carbonate solution of concentration 0.200 mol dm^{-3} using a correct method. She took 25.0 cm^3 samples of the sodium carbonate solution and titrated these using a solution of sulfuric acid, H_2SO_4, of unknown concentration. The acid was placed in the burette.

Describe how Emily should perform one titration to find the volume of sulfuric acid needed for complete reaction. [4]

QWC [1]

Total [10]

Turn over.

8. *(a)* A student was given an aqueous solution of iodic(V) acid, HIO_3, and was asked to find its concentration by titration with sodium hydroxide solution.

$$NaOH + HIO_3 \longrightarrow NaIO_3 + H_2O$$

He rinsed the burette with water and then filled it with the iodic(V) acid solution. 25.0 cm^3 of sodium hydroxide solution of concentration 0.125 mol dm^{-3} were used for each titration against the aqueous iodic(V) acid. The following results were obtained.

Titration	1	2	3	4	5
Volume of iodic(V) acid solution used / cm^3	19.20	18.60	18.70	18.55	18.55

(i) Sodium hydroxide is described as a base. State what is meant by the term *base*. [1]

....

....

(ii) The teacher said that the result of titration 1 was too high. State **one** reason why a fault in the practical method could explain this result. [1]

....

....

(iii) Use the results from titrations 2 to 5 to calculate the mean volume of iodic(V) acid solution and hence the concentration of the acid in mol dm^{-3}. [3]

Concentration of iodic(V) acid = ... mol dm^{-3}

(iv) Iodic(V) acid is an expensive material to use and a student suggested that it would be more economical if only 10.00 cm^3 of sodium hydroxide solution were used for each titration.

Suggest **one** reason why this was not done in this experiment. [1]

....

....

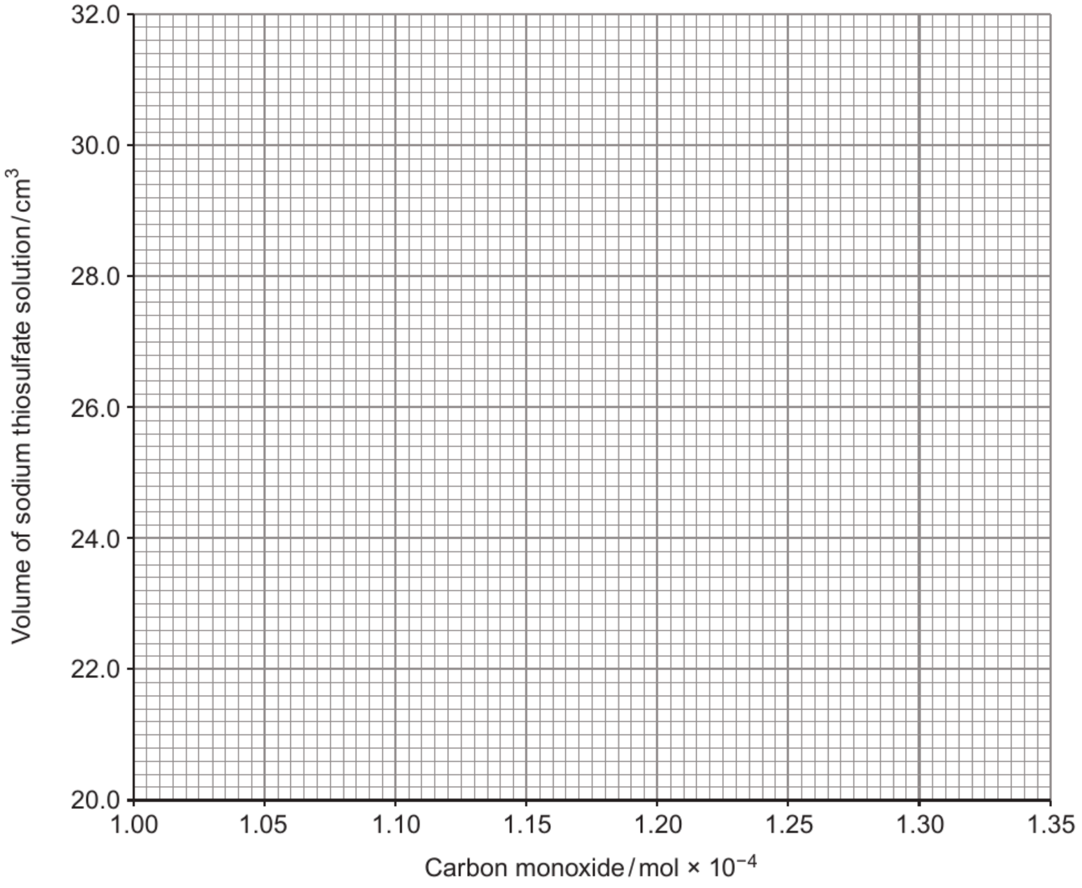
....

(b) The percentage by volume of carbon monoxide in a gas mixture can be found by reacting it with an iodine compound, and titrating with sodium thiosulfate solution, from which the number of moles of carbon monoxide present can be found.

Two results obtained by this method are shown below.

Volume of sodium thiosulfate solution / cm^3	23.5	30.2
Carbon monoxide / mol × 10^{-4}	1.05	1.30

(i) Plot these two points on the grid provided and then join them with a straight line. [1]



(ii) In an experiment the carbon monoxide in a gas mixture of volume 300 cm^3 gave a reading of 28.40 cm^3 of sodium thiosulfate solution.

Use your graph to find the number of moles of carbon monoxide present in the gas mixture and hence calculate the percentage by volume of carbon monoxide in the gas mixture. Give your answer to **three** significant figures. [3]
[1 mol of any gas has a volume of 24 000 cm^3 at the conditions used]

Percentage of carbon monoxide by volume = ... *%*

(c) Harmful gases from vehicle exhausts include carbon monoxide and nitrogen(II) oxide, NO. In a catalytic converter these two gases are converted to nitrogen and carbon dioxide by passing them over a mixture of platinum and rhodium metals.

Give the equation for this reaction. [1]

....

(d) Catalysts are very important in many industrial processes.

Discuss how catalysts

- increase the rate of a reaction
- affect equilibrium reactions

[4]
QWC [1]

Total [16]

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END OF QUESTION PACK

9 questions · 98 marks · ~2 h 37 min
Source: WJEC CH1 (2008 modular spec, Jan 2009 – Jun 2016)
Curated for WJEC Chemistry 2015 spec AS Unit 1 — Topic 7 (1.3 / 1.7)