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ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2025

Centre Number

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Candidate Number

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Life and Health Sciences

Assessment Unit AS 3

assessing

Aspects of Physical Chemistry in
Industrial Processes



[SZ031]

SZ031

MONDAY 2 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete questions in black ink and use a dark HB pencil for drawings and graphs.

Do not write with a gel pen.

Answer **all five** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 75.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

You may use a scientific calculator.

Quality of written communication will be assessed in Question **4(b)(ii)**.

A Data Leaflet, which includes a Periodic Table of Elements, is included in this question paper.

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20SZ03101

1 The Haber process is used to manufacture ammonia on an industrial scale. This is a continuous process and uses a catalyst.

(a) (i) Define the term **continuous process**.

_____ [2]

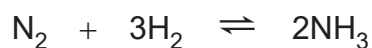
(ii) State **two** factors that must be taken into consideration with regard to infrastructure when choosing a site for an industrial production plant for manufacturing ammonia.

1. _____

2. _____

_____ [2]

(b) The balanced symbol equation for the Haber process is as follows:



(i) What does \rightleftharpoons mean?

_____ [1]

(ii) State the temperature, pressure and catalyst used in the Haber process.

Temperature	Pressure	Catalyst
_____ °C	_____ atm	_____

[3]



(iii) Show that the number of moles that are present in 2000 kg of nitrogen gas is 71428.57.

[3]

(iv) Calculate the relative formula mass of ammonia.

_____ [1]

(v) Use your answer from (iv) and the equation in (b) to calculate the theoretical yield of ammonia, in kilograms, that can be made using 71428.57 moles of nitrogen gas.

Give your answer to **two decimal places**.
Show your working out.

_____ kg [3]

[Turn over

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20SZ03103

(vi) The percentage yield of this reaction is 25%.

Use this information and your answer from (v) to calculate, in kilograms, the actual yield of ammonia produced.

_____ kg [1]

(vii) Suggest a reason why the percentage yield for this reaction is only 25%.

_____ [1]





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20SZ03105

- 2 (a) Ammonia can be oxidised in the presence of a platinum–rhodium catalyst to make nitrogen monoxide.

The equation for the reaction is:



- (i) Define the term **catalyst**.

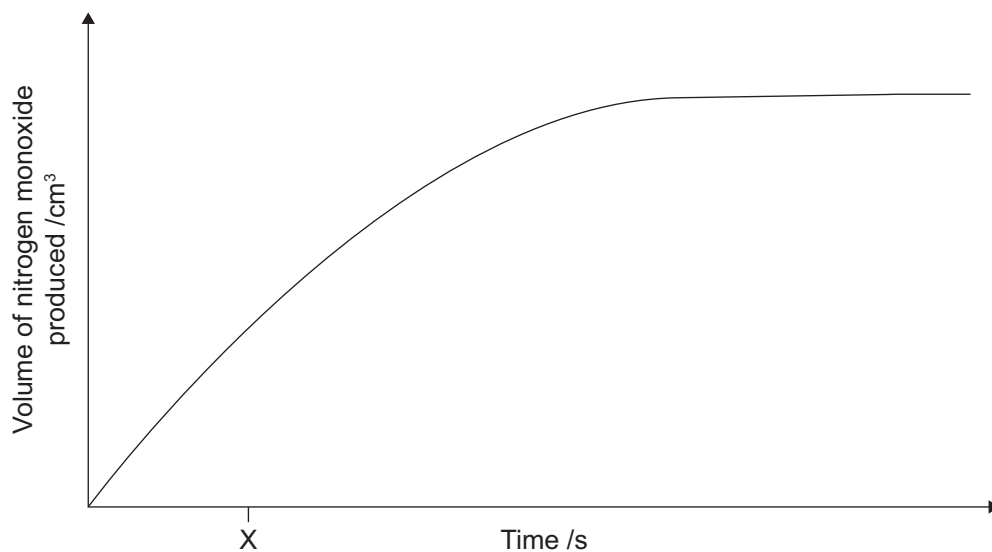
_____ [2]

- (ii) What term describes the type of catalysis when the catalyst is in a different physical state to the reactants?

_____ [1]



The graph below shows the volume of nitrogen monoxide produced against time for the oxidation of ammonia reaction **without** a catalyst.



(iii) Explain how you would use the graph to determine the rate of the reaction at time X.

_____ [1]

(iv) On the graph, sketch the curve you would expect to see for the same reaction in the presence of a catalyst. [1]

(b) State and explain the effect on the rate of a chemical reaction if it is carried out at a higher temperature.

Effect on rate _____

Explanation _____

_____ [3]

[Turn over



3 In a titration, 25.0 cm^3 of sodium hydroxide solution was titrated with a standard solution of 0.1 mol dm^{-3} sulfuric acid.
The results were used to determine the concentration of the sodium hydroxide solution.

(a) (i) Describe how you would carry out this titration.

Your answer should include how to:

- measure out and transfer the 25.0 cm^3 of sodium hydroxide solution into the conical flask;
- prepare and fill the burette; and
- carry out an accurate titration.

Measure out and transfer the sodium hydroxide solution

Prepare and fill the burette

Carry out an accurate titration

[8]



- (ii) Name a suitable indicator for this titration and state the colour change at the end point.

Indicator _____

From _____ to _____ [3]

- (b) The results of the titration are given below.

	Initial burette reading /cm ³	Final burette reading /cm ³	Titre /cm ³
Rough	0.0	15.2	15.2
Run 1	0.0	14.9	14.9
Run 2	0.1	_____	14.4
Run 3	_____	14.6	14.5

- (i) Complete the results table above by adding in the missing values. [2]

- (ii) Calculate the mean titre and justify the choice of titres used in your calculation.
Give your answer to **one decimal place**.

Mean titre _____ cm³

Justification _____

_____ [2]

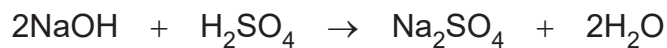
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- (c) Another student carried out the same titration and obtained a mean titre of 15.0 cm^3 .

The student used 25.0 cm^3 of sodium hydroxide solution.

The balanced symbol equation for the reaction is:



- (i) Use this mean titre to calculate the number of moles of 0.1 mol dm^{-3} sulfuric acid solution used in this titration.

Show your working out.

_____ moles [2]

- (ii) Use your answer to (c)(i) and the equation to calculate the concentration of the sodium hydroxide solution.

Show your working out.

_____ mol dm^{-3} [2]





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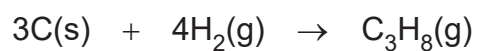
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20SZ03111

4 (a) The equation for the formation of propane is as follows:



(i) Using this equation and the data below, calculate the standard enthalpy change of formation of propane (C_3H_8).

Show your working out.

	Enthalpy change of combustion / kJ mol^{-1}
Carbon	-394
Hydrogen	-286
Propane	-2220

_____ kJ mol^{-1} [4]



(ii) On the axes below, draw and label the reaction profile diagram you would expect for an exothermic reaction.

Label the axes.



[3]

[Turn over

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20SZ03113



[6]

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[Turn over



20SZ03115

(c) During the experiment, 0.23 g of propanol was burned completely in air and the following measurements were recorded.

Temperature at start /°C	Maximum temperature reached /°C	Volume of water /cm ³
18	29	100

- (i) Assuming there was no heat loss to the environment, calculate the heat energy produced by this combustion reaction.
The specific heat capacity of water is 4.2 J g⁻¹ °C⁻¹.

**Include units in your answer.
Show your working out.**

_____ [3]
Units _____ [3]

- (ii) Calculate the number of moles of propanol (C₃H₇OH) used in this experiment.

**Give your answer to four decimal places.
Show your working out.**

_____ moles [3]



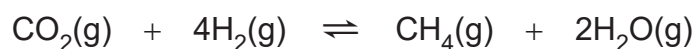
(iii) Use your answers from parts (i) and (ii) to calculate the enthalpy change of combustion of propanol in kJ mol^{-1} .

**Give your answer to the nearest whole number.
Show your working out.**

_____ kJ mol^{-1} [3]



- 5 The reaction between carbon dioxide and hydrogen produces methane and steam.



In a sealed container this reaction forms a dynamic equilibrium.

- (a) Define the term **dynamic equilibrium**.

[2]

- (b) The table below shows the percentage yield of methane in the equilibrium mixture under different conditions.

		Temperature /°C			
		300	600	900	1200
Pressure /atm	100	35%	30%	23%	14%
	200	52%	46%	37%	25%
	300	73%	68%	57%	36%
	400	80%	75%	62%	48%
	500				

- (i) From the table above, state the conditions that produce the maximum percentage yield of methane.

[1]



(ii) Use your understanding of equilibrium to explain why **increasing the temperature** in this reaction **decreases the yield** of methane.

[2]

(iii) Use your understanding of equilibrium to explain why **increasing the pressure** in this reaction **increases the yield** of methane.

[2]

THIS IS THE END OF THE QUESTION PAPER



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For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	

Total Marks	
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Examiner Number

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20SZ03120

AS 3 and A2 2
Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

**Copies must be free from notes or additions of any
kind. No other type of data booklet or information
sheet is authorised for use in the examinations**

gce a/as examinations
life & health
sciences

THE PERIODIC TABLE OF ELEMENTS

Group

I	II											III	IV	V	VI	VII	0
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La [*] Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac [†] Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						
			140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71	
			232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103	

* 58–71 Lanthanum series

† 90–103 Actinium series

a	x
b	

a = relative atomic mass (approx)

x = atomic symbol

b = atomic number