Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022

Centre Number

Candidate Number

Life and Health Sciences

Assessment Unit AS 3
assessing
Aspects of Physical Chemistry in Industrial Processes

[SZ031]

SZ031

THURSDAY 9 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

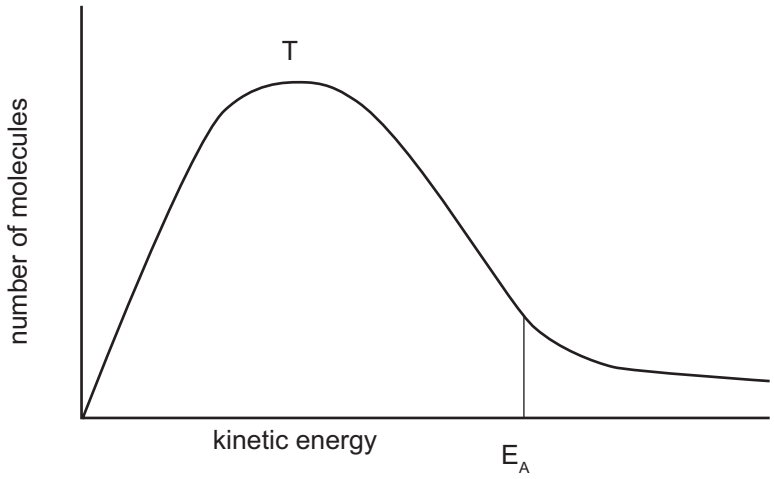
INSTRUCTIONS TO CANDIDATES

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 in black ink only. **Do not write with a gel pen.**
Answer **all six** questions.
Write your answers in the spaces provided in this question paper.

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.
A Periodic Table of Elements is included in this question paper.
You may use an electronic calculator.
Quality of written communication will be assessed in Question **4(d)(iv)**.

1 The graph below shows the distribution of energies that gaseous molecules possess during a reaction at temperature T.



(a) (i) What name is given to this type of distribution curve?

_____ [1]

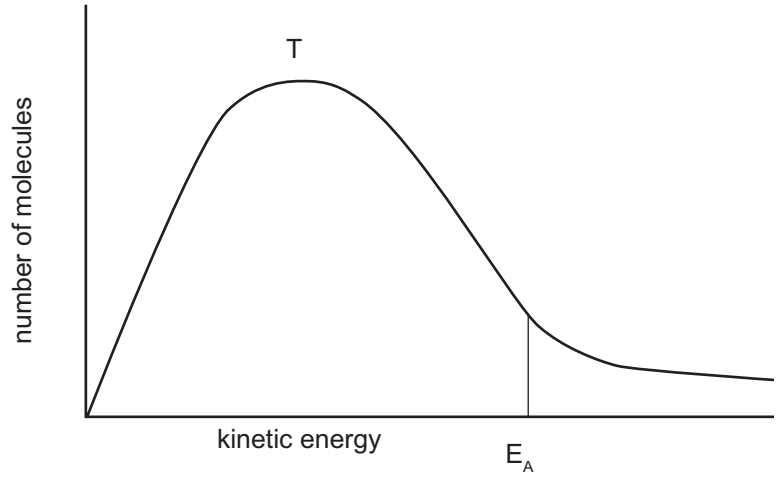
(ii) The label E_A on the x-axis represents the activation energy for this reaction. Define the term **activation energy**.

_____

_____ [2]

(iii) On the graph above, shade the area that represents the number of molecules that will react at temperature T. [1]

(b) (i) On the graph below, add another curve that would represent the same reaction at a **lower** temperature T_1.



[3]

(ii) With reference to the distribution curves, explain why this reaction is slower at the lower temperature, T_1.

_____

_____

_____

_____

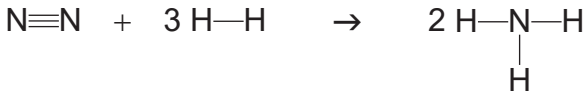
_____ [2]

(iii) State **one** other factor that would lower the rate of this reaction.

_____ [1]

[Turn over

2 Ammonia is manufactured using the Haber process.
The structural equation for the reaction is shown below.



(a) (i) Name the catalyst used in the Haber process.

_____ [1]

(ii) Complete the table below to show the conditions required for the Haber process. Include units in your answer.

Pressure	
Temperature	

[2]

(b) Use the average bond enthalpies given below to calculate the enthalpy change for this reaction.

Bond	Average bond enthalpy /kJ mol^{-1}
N—N	163
N═N	418
N≡N	946
H—H	436
H—N	389

_____ kJ mol^{-1} [3]

(c) On the axes below, draw a reaction profile diagram for the Haber process.
The reaction is exothermic.
Label the axes.

[3]

(d) The reaction of nitrogen and hydrogen is a reversible reaction.
In a closed system this is an example of dynamic equilibrium.

(i) Insert the symbol in the equation below to indicate that this reaction is reversible.

$$N_2 + 3H_2 \qquad 2NH_3$$

[1]

(ii) Define the term **dynamic equilibrium**.

_____

_____ [2]

(e) Ammonia can react with sulfuric acid to produce ammonium sulfate. Complete and balance the equation for this reaction.

$$NH_3 \quad + \quad H_2SO_4 \rightarrow$$

[1]

[Turn over

3 To set up a new chemical manufacturing plant, the developer must take many different aspects into account.

The Northern Ireland Environment Agency requires consideration to be given to several environmental factors including:

- drainage;
- waste water treatment;
- pollution prevention; and
- strategies to control major accident hazards.

Where the application site involves developed, derelict or brownfield land, there may be many habitat surveys required.

(a) Apart from environmental factors, give **one** other consideration when siting a new chemical manufacturing plant.

_____ [1]

(b) Describe **one** type of pollution that needs to be minimised.

_____

_____ [1]

(c) Define and give **one** example of capital costs.

_____

_____ [2]

[Turn over

4 One of the main chemicals in petrol is octane (C_8H_{18}).

In the engine of the car, this burns to produce energy. Hess's law can be used to determine the enthalpy of combustion of octane.

(a) State **Hess's law**.

_____

_____ [2]

(b) Define the term **standard enthalpy of combustion**.

_____

_____ [2]

(c) **(i)** Octane burns as shown by the equation below:

$$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(l)$$

Use the enthalpy of formation values below to calculate the enthalpy change of this reaction.

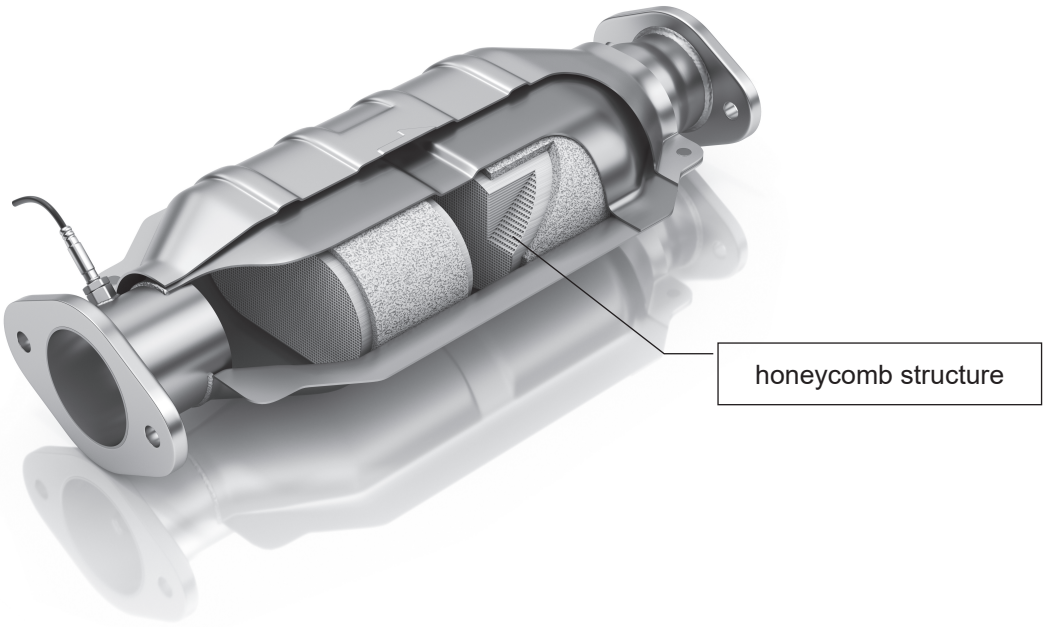
$C(s) + O_2(g) \rightarrow CO_2(g)$	Enthalpy of formation of $CO_2 = -393.5\,kJ\,mol^{-1}$
$8C(s) + 9H_2(g) \rightarrow C_8H_{18}(l)$	Enthalpy of formation of $C_8H_{18} = -250.0\,kJ\,mol^{-1}$
$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$	Enthalpy of formation of $H_2O = -286.0\,kJ\,mol^{-1}$

_____ kJ [3]

(ii) Using your answer to **(c)(i)**, calculate the enthalpy of combustion of **one** mole of octane.

_____ kJ mol^{-1} [1]

(d) A catalytic converter is used in a car to help reduce harmful emissions from the burning of octane.



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(i) Name **one** of the main metals present in a catalytic converter.

_____ [1]

(ii) Suggest a reason for the honeycomb structure inside the catalytic converter.

_____

_____ [1]

[Turn over

(iii) Explain why this catalysis in the converter is an example of **heterogeneous** catalysis.

[1]

(iv) Describe how the heterogeneous catalyst in a catalytic converter works.

Your answer should include:

- how the catalyst works;
- the name and a description of the process involved; and
- an explanation of catalytic poisoning.

Quality of written communication will be assessed in this question.

[6]

[Turn over

(e) The efficiency of a catalytic converter depends on the temperature of the vehicle engine.

The graph below shows one catalytic converter's efficiency at converting different components of the exhaust gases.

Extract removed due to Copyright

(i) Use this data to suggest why a catalytic converter is not useful for short journeys.

_____

_____ [1]

(ii) Describe the graph and the general trend shown by this data for carbon monoxide.

_____

_____

_____

_____

_____

_____ [2]

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(Questions continue overleaf)

[Turn over

5 A student carried out an experiment to determine the enthalpy change for the following reaction:

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

He measured 50.0 cm^3 of aqueous copper(II) sulfate and placed it in a polystyrene cup.
He recorded the initial temperature as 21.0°C.
He added a known mass of zinc powder to the polystyrene cup.
The temperature rose to 31.4°C.

The mass of copper metal formed during the reaction was 0.32 g.

Assume the mass of copper(II) sulfate solution is 50.0 g and the specific heat capacity of the solution is 4.2 $Jg^{-1}K^{-1}$.

(a) Name a piece of apparatus that would be suitable to measure out the copper(II) sulfate solution.

_____ [1]

(b) Suggest why a polystyrene cup was used instead of a beaker.

_____ [1]

(c) **(i)** Calculate the temperature rise for this reaction.

_____ [1]

(ii) Calculate the heat energy change, Q, of this reaction.

_____ J [3]

(iii) Calculate the number of moles of copper produced.

_____ moles [1]

(iv) Calculate the energy released per mole of copper.
Give your answer in kilojoules.

_____ kJ [2]

(v) Suggest **one** improvement to this method to help reduce errors.

_____

_____ [1]

[Turn over

6 An unknown concentration of sulfuric acid was titrated with 0.20 M sodium hydroxide. The results were used to calculate the concentration of the sulfuric acid.

(a) The sodium hydroxide used was a standard solution made from sodium hydroxide pellets.

(i) Why is it important that the sodium hydroxide was a standard solution?

_____

_____ [1]

(ii) Calculate the mass of sodium hydroxide required to make 500 cm^3 of the 0.20 M standard solution.

_____ g [2]

(iii) Apart from wearing safety goggles, state **one** safety precaution that would need to be taken when using solid sodium hydroxide pellets.

_____ [1]

(iv) Describe how 500 cm^3 of this standard solution should be made.

[6]

[Turn over

(b) 25.0 cm^3 of the unknown sulfuric acid solution was added to a conical flask and a few drops of phenolphthalein indicator were added.

(i) Explain why phenolphthalein is a suitable indicator for this titration.

_____

_____ [1]

(ii) Complete the table below to show the colour of phenolphthalein in acid and alkali.

	Acid	**Alkali**
Colour of phenolphthalein		

[2]

(c) The titration was carried out and the results are shown below.

	Rough titre	**First accurate titre**	**Second accurate titre**
Volume of sodium hydroxide /cm^3	39.0	37.5	37.6

(i) Calculate the average titre.
Give your answer to one decimal place.

_____ cm^3 [1]

(ii) Why is it important to repeat the titration?

_____ [1]

(iii) Using your answer to **(c)(i)**, calculate the number of moles of 0.20 M sodium hydroxide used in the titration.

_____ moles [1]

The equation for the reaction is shown below:

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

(iv) Calculate the number of moles of sulfuric acid that reacted in this titration.

_____ moles [1]

(v) Calculate the concentration of the sulfuric acid sample (25.0 cm^3) in mol dm^{-3}.

_____ mol dm^{-3} [1]

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	
6	
Total Marks	

Examiner Number

Rewarding Learning

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

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Rewarding Learning

11409.02

Subject Code: 0008

THE PERIODIC TABLE OF ELEMENTS

I	II											III	IV	V	VI	VII	0
Group																	
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
b x

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

11409.02