Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2024

Centre Number

Candidate Number

Life and Health Sciences

Assessment Unit AS 3

assessing

Aspects of Physical Chemistry in Industrial Processes

SZ031

[SZ031]

MONDAY 3 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.

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 **3**.

1 Nitrous oxide (N_2O) has traditionally been used as an anaesthetic.

It is produced by the thermal decomposition of ammonium nitrate in a continuous process.

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

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

_____

_____ [2]

(ii) State **one** way in which a continuous process reduces costs compared to a batch process.

_____

_____ [1]

(b) Calculate the relative formula mass of:

(i) NH_4NO_3

_____ [1]

(ii) N_2O

_____ [1]

(iii) Calculate the mass, in kilograms, of ammonium nitrate needed to make 143 kg of nitrous oxide.

Show your working.

_____ kg [2]

(iv) Calculate the percentage yield of nitrous oxide achieved if only 109 kg of it is formed instead of the expected 143 kg.

Give your answer to one decimal place.

_____ % [1]

(v) Suggest **one** reason why the yield is not 100%.

_____

_____ [1]

(c) A new chemical manufacturing plant is to be built to produce large volumes of nitrous oxide.

Suggest **one** way that the building of this new plant could benefit the community.

_____

_____ [1]

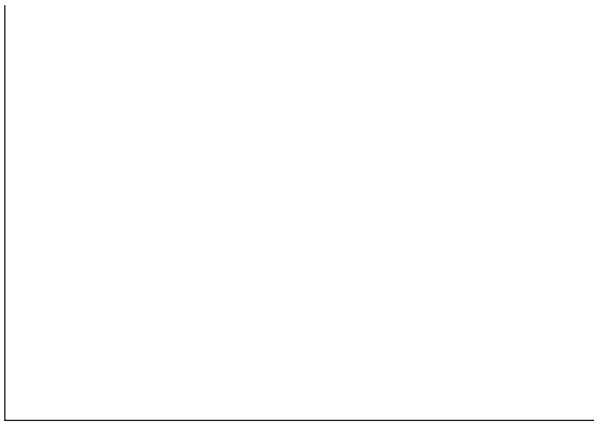
[Turn over

2 Chemical reactions can be exothermic or endothermic.

(a) (i) Using the axes below, construct a reaction profile diagram for an endothermic reaction.

You must label:

- both axes
- reactants and products
- activation energy (E_A)



[4]

(ii) Explain how the reaction profile diagram you have drawn shows that the reaction is endothermic.

_____

_____ [1]

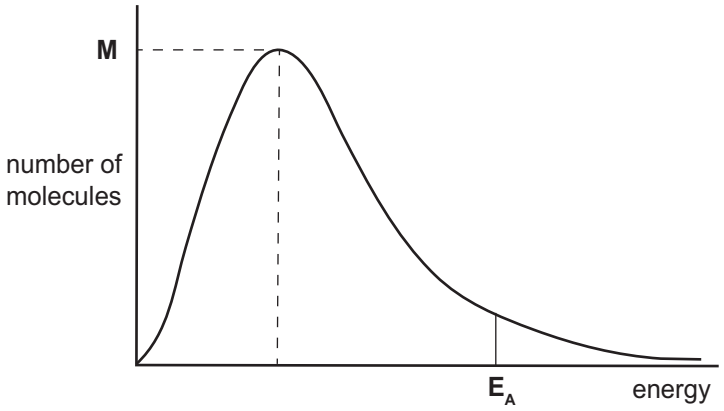
(iii) Define **activation energy**.

_____

_____ [2]

(b) The curve below shows the distribution of energies that gaseous molecules possess during a reaction.

M is the number of molecules with the most common energy and $\mathbf{E_A}$ is the activation energy.



Source: Principal Examiner

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

_____ [1]

(ii) The temperature of the gas is increased.

What is the effect on E_A and M?

Tick (✓) the correct box.

E_A	M	effect
decrease	increase	
decrease	decrease	
constant	increase	
constant	decrease	

[1]

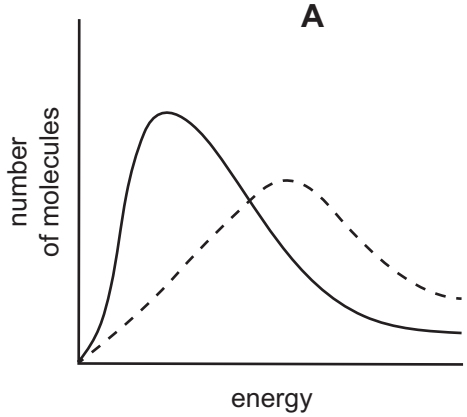
(iii) On the curve above, shade the area that represents the number of molecules that can successfully react. [1]

[Turn over

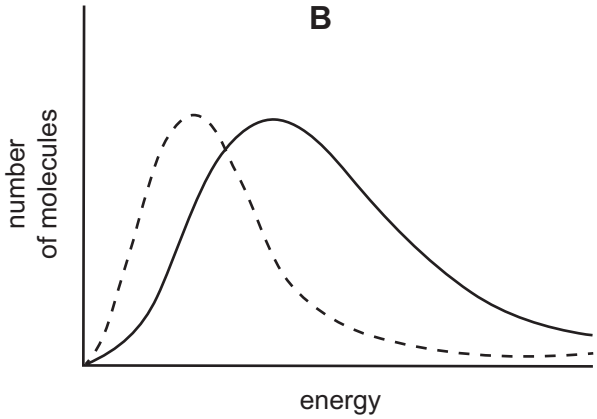
(iv) The diagrams below labelled **A**, **B**, **C** and **D** show a dashed curve for the distribution of energies that gaseous molecules possess at **400 K** for four different reactions.

Which of the diagrams (**A**, **B**, **C** or **D**) correctly shows a **solid** curve which represents the distribution of energies that gaseous molecules possess at **250 K** for that reaction?

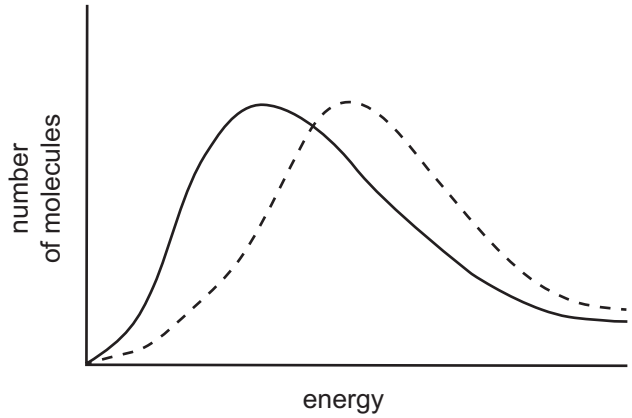
A



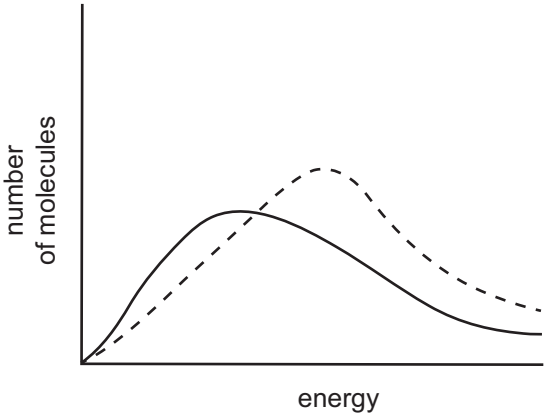
B



C



D



Source: Principal Examiner

diagram _____ [1]

3 A chemist decides to carry out an experiment to determine the rate of a reaction between calcium carbonate pieces and excess nitric acid.

During this reaction a gas is produced and collected.

Describe how you would use a gas syringe to follow this reaction.

Explain how the results collected could be used to determine the rate of the reaction.

Quality of written communication will be assessed in this question.

[6]

4 Sulfuric acid is manufactured in the Contact process.
The second stage in this process involves passing sulfur dioxide and oxygen over a heated catalyst to produce sulfur trioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -196\,kJ\,mol^{-1}$$

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

_____

_____ [2]

(ii) Name the catalyst used in the Contact process.

_____ [1]

(iii) State **one** direct cost involved in this process.

_____ [1]

(b) The yield of sulfur trioxide obtained in this dynamic equilibrium can be improved by changing some of the conditions.

(i) Define **dynamic equilibrium**.

_____

_____

_____ [2]

(ii) Using your knowledge of equilibrium, state and explain what would happen to the yield of sulfur trioxide obtained in this reaction if the temperature is increased **or** the pressure is increased.
All other conditions remain the same.

Increasing the temperature

Effect on yield

Explanation

Increasing the pressure

Effect on yield

Explanation

[4]

(iii) State one **disadvantage** of using high pressures in industry.

[1]

(c) Sulfur trioxide reacts with water to produce sulfuric acid.

Write a balanced symbol equation for this reaction.

[2]

[Turn over

5 The enthalpy of combustion of a liquid fuel can be determined experimentally by burning the fuel in a spirit burner.

The energy released is used to raise the temperature of a known mass of water.

(a) State **all** the equipment needed to determine the enthalpy of combustion of ethanol.

_____

_____

_____ [3]

(b) The results obtained from this experiment are shown below.

Mass of water	150.00 g
Mass of spirit burner and ethanol at start	62.09 g
Mass of spirit burner and ethanol at end	60.94 g
Temperature of water at start	22°C
Temperature of water at end	43°C

(i) Calculate the temperature change of the water in this experiment.

_____ °C [1]

(ii) Write the equation used to calculate the energy transferred to the water in this experiment.

_____ [1]

(iii) Calculate the energy transferred to the water in this experiment.
The specific heat capacity of water is $4.2\,Jg^{-1}°C^{-1}$.

Show your working.

Include units in your answer.

_____

unit = _____ [3]

(iv) Calculate the number of moles of ethanol burned in this experiment.
The relative formula mass of ethanol is 46.

Show your working.

_____ moles [2]

[Turn over

(v) Use the answers to parts **(iii)** and **(iv)** to calculate the experimentally determined value for the enthalpy of combustion of one mole of ethanol.

Show your working.

Include units in your answer.

_____

unit = _____ [3]

(vi) State **one** source of error when experimentally determining the enthalpy of combustion of ethanol and explain how this source of error could be reduced.

Source of error

_____

How error could be reduced

_____

_____ [2]

(c) (i) Calculate the theoretical enthalpy of combustion for ethanol using a Hess Cycle.

The equation for the reaction and enthalpy of formation data is given below.

Show your working.

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

	C_2H_5OH	O_2	CO_2	H_2O
Enthalpy of formation /kJ mol^{-1}	–278	0	–394	–286

_____ kJ mol^{-1} [3]

(ii) Suggest why the enthalpy of formation of oxygen is zero.

_____

_____ [1]

[Turn over

6 A lab technician carried out a titration to determine the molarity of a solution of ethanoic acid (CH_3COOH) using a standard solution of sodium hydroxide (NaOH).

(a) Calculate the concentration of the standard solution formed when 24.0 g of sodium hydroxide is dissolved in 500 cm^3 of water.

Show your working.

_____ mol dm^{-3} [3]

(b) Describe how the technician accurately prepared 500 cm^3 of the standard sodium hydroxide solution.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

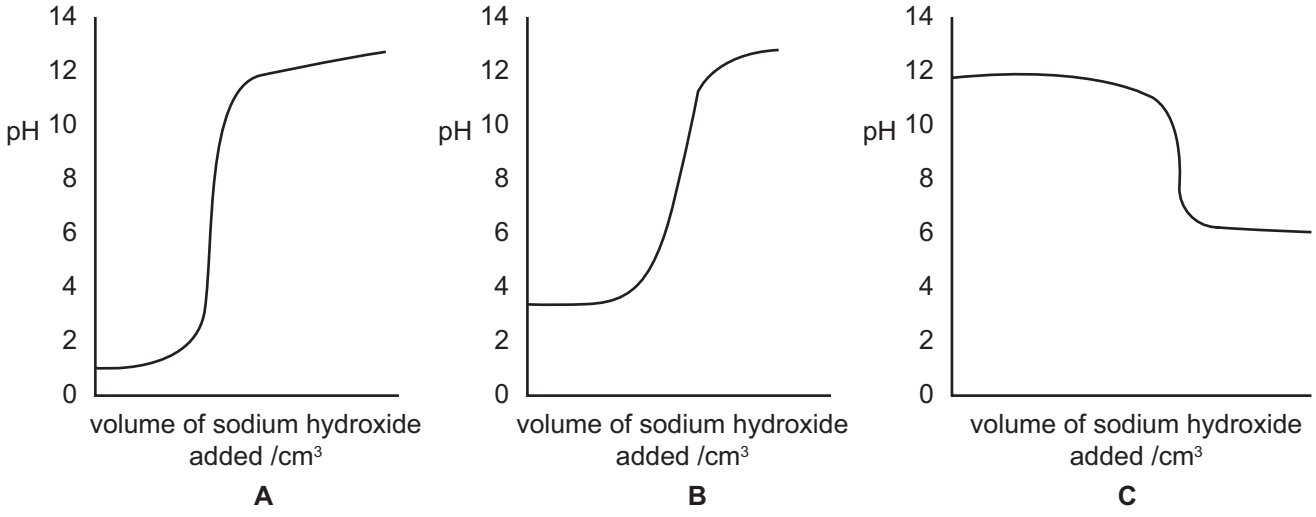
_____ [6]

(c) Draw and label a diagram of the assembled apparatus used to titrate 25.0 cm^3 of ethanoic acid solution with the standard solution of sodium hydroxide.

Clearly indicate the location of each solution in your diagram.

[3]

(d) Suggest which **one** of the following curves, **A**, **B** or **C**, best represents the titration between ethanoic acid and sodium hydroxide.



Source: Principal Examiner

curve _____ [1]

[Turn over

(e) State a suitable indicator for the titration between ethanoic acid and sodium hydroxide, and state the colour change at the end point.

Indicator _____

Colour change

from _____ to _____ [3]

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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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life & health sciences

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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