Module 4: Energy

Further exercises

For page 248

A1. By comparing your lifestyle with that of South-East Asian peasant farmers, list ways in which your energy consumption is greater than theirs.

A2. Suggest ways in which you and your family could use less energy without your lifestyle deteriorating significantly.

A3. It is sometimes said that when we eat food such as bread, fruit and vegetables and meat we are eating not just sunlight but also lots of fossil fuel. Justify this statement.

A4. Of the various forms of energy that are commonly used today, list four that come from sources other than fossil fuels. Also list four that currently come from fossil fuels but which could come from non-fossil-fuel sources.

For page 255

B1. Silicon carbide, SiC (carborundum), has some properties similar to those of diamond. Offer an explanation for this in terms of the chemical structure you would expect for this compound.

B2. Phosgene, $COCl_2$ has two Cl atoms and an O atom attached to a central C atom. Draw an electron-dot structure and structural formula for this compound.

B3. In which of the following compounds would you expect to find a double bond:
(a) C_3H_8 **(b)** C_4H_8 **(c)** C_5H_{12} **(d)** C_7H_{14}
Explain why.

For page 263

C1. The structural formulae of two alkanes are sometimes written as
(a) $CH_3CH_2CH_2CH_2CH_3$ and (b) $CH_3(CH_2)_5CH_3$
Draw the complete structural formulae (as in Table 9.8 on page 261) for these two compounds.

C2. Explain what is meant by the statement, alkanes are a subset of a class of compound called hydrocarbons.

C3. Although structural formulae for ethane and propane are often drawn as in Table 9.8 on page 261, these do not accurately represent the geometry of the molecules. Draw structural formulae for these compounds that more accurately reflect the true geometry of the molecules.

C4. Is it possible to have isomers of butane, C_4H_{10}? If so draw their structures.

For page 266

D1. The percentage composition of all alkenes is the same, namely 85.6% C and 14.4% H, but the percentage composition of alkanes varies from one alkane to another. Illustrate the latter point by calculating the percentage composition of
(a) ethane and (b) octane.
Explain why the percentage composition of alkanes varies while that of alkenes is constant.

D2. Near the bottom of page 264 the boiling points and densities of two isomers of butene are given; it is stated in a footnote that there is a third isomer of butene. Draw its structure.

There are no **E** *exercises*

For page 272

F1. List the safety precautions you would take for storing and handling kerosene in the home. Why is kerosene blue?

F2. In which commercial product(s) would you find
(a) ethane (b) heptane (c) butane (d) hydrocarbons of formula $C_{16}H_{34}$
(e) unsaturated C_8 and C_{10} compounds (f) hydrocarbons with C_{30} to C_{34}?

For pages 279–80

G1. When 1.00 g barium was dropped into 100 mL (= 100 g) water at 18.2°C, reaction occurred to form barium hydroxide solution and hydrogen gas. The temperature rose to 30.4°C. Write an equation for the reaction and calculate its ΔH. Assume that the heat capacity of the final solution is that of water, namely 4.2 J K^{-1} g^{-1}, that the heat capacity of the calorimeter (beaker) is negligible and that there were no heat losses to the surroundings.

G2. Quick lime, calcium oxide, reacts with water to form slaked lime, calcium hydroxide. When 3.10 g calcium oxide was added to 250 mL water in a polystyrene beaker, the temperature rose by 4.2°C. Write an equation for the reaction and calculate ΔH for it making the same assumptions as in exercise G3.

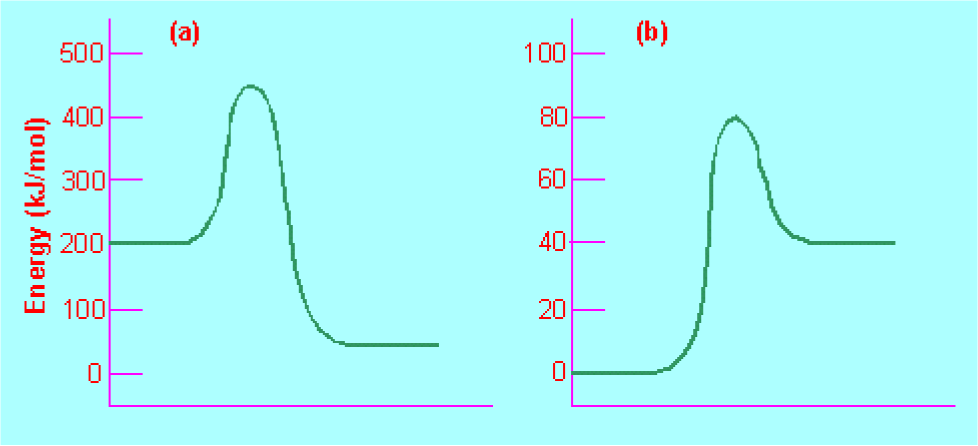
For pages 281–2

H1. 0.58 g butane was burnt with excess oxygen in a closed container immersed in 500 g water at 15.3°C. After complete reaction the temperature of the water was 29.0°C (after correction to constant pressure conditions). Assuming that the heat capacity of the container and its contents is negligible (compared to that of the water), calculate the heat of combustion of butane. The specific heat capacity of water is 4.2 J K^{-1} g^{-1}.

For pages 283 and 285

J1. To bring about the reaction
$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$
what bonds have to be broken and what new bonds have to be made? This reaction is exothermic. What can you say about the relative strengths of the bonds being broken and those being made?

J2. The diagrams below show energy profiles for the reactions
(a) A + B $\rightarrow$ C
(b) 2L $\rightarrow$ M + N
Determine ΔH and E_a for each of these reactions.



For page 289

K1. Heating houses by burning wood in slow combustion stoves is often considered to contribute less to global warming (greenhouse effect) than generating the same amount of energy by burning natural gas. Explain why. What are the disadvantages in heating houses by burning wood?

K2. When octane burns in air, depending upon the conditions being used, the carbon products can be solely carbon dioxide, a mixture of carbon monoxide and dioxide or a mixture of soot (carbon) and the two oxides. Write a balanced chemical equation for each of these three situations. What conditions favour the formation of (a) solely carbon dioxide and (b) soot plus oxides of carbon?

K3. The main pollutants produced by cars with petrol engines are unburnt (or partially burnt) hydrocarbons, carbon monoxide and oxides of nitrogen. Cars with diesel engines produce significantly less hydrocarbon and carbon monoxide but much more oxides of nitrogen. In diesel engines the air to fuel ratio is much higher than in petrol engines. Explain how these different air to fuel ratios lead to the different amounts of pollutants.

For pages 293–4

Exercises L1 and L4 involve quantitative measurements of rate of reaction as discussed in the Supplementary material section; it is probably not required for the NSW HSC.

L1. Hydrogen peroxide decomposes in alkaline solution:

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The concentration of hydrogen peroxide was determined at various times after mixing peroxide and alkali solutions:

Time (s)	0	1500	3000	4000	6000	9000	12 000
Conc of H_2O_2 (mol/L)	0.16	0.14	0.125	0.115	0.098	0.078	0.065

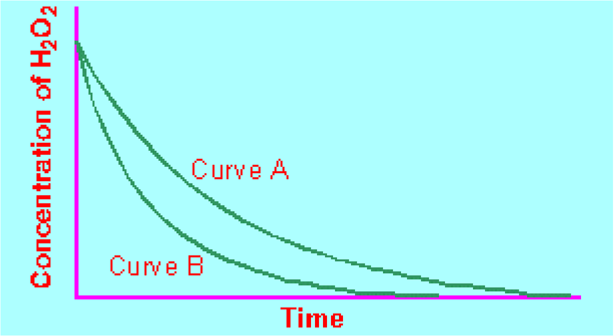
Draw a graph of concentration of H_2O_2 versus time. Calculate the average rate of reaction over the first 3000 s, and over the time intervals, 5000 to 8000 s, and

10 000 to 12000 s. How does rate change as reaction proceeds?

L2. The diagram below shows the decrease in hydrogen peroxide concentration with time for two experiments in which acidified solution of hydrogen peroxide is mixed with iodide solution. The reaction is

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

The concentrations of hydrogen peroxide and acid and the temperature were the same in both experiments. In one experiment the concentration of iodide was 0.20 mol/L while in the other it was 0.40 mol/L. Which curve belongs to which concentration? Explain how you reached your decision.



Copy curve A to your workbook. On this graph draw the curve you would expect for the concentration of iodine as a function of time in this experiment. Keep this graph for exercise M1 below.

L3. The effect of stirring upon the rate of the reaction between magnesium and dilute sulfuric acid was studied in the following way. A weighed piece of magnesium ribbon was suspended in a solution of the acid and a stopwatch started. Periodically the stopwatch was stopped as the piece of magnesium was removed from the solution, rinsed, dried and weighed. The magnesium was placed back in the solution and the stopwatch restarted. Results from two experiments are shown below. In Experiment A there was no stirring while in Experiment B the solution was continuously and vigorously stirred.

Experiment A (no stirring)						
Time (min)	0	1.0	2.0	3.5	5.0	7.0
Mass of piece of Mg (g)	5.00	4.82	4.65	4.45	4.31	4.18

Experiment B (vigorous stirring)						
Time (min)	0	0.50	1.50	3.0	5.0	7.0
Mass of piece of Mg (g)	5.00	4.81	4.54	4.30	4.14	4.05

(a) Write an equation for the reaction being studied.

(b) Graph the results for the two experiments on the one piece of graph paper and draw appropriate curves or lines through the points.

(c) From these results, what is the effect of stirring upon the rate of reaction? Explain how you reached your conclusion.

(d) Offer an explanation for *why* stirring should have this effect upon rate of reaction.

(e) Suppose the experiment had been repeated using 5.00 g of a much thinner piece of magnesium ribbon so that the surface area of magnesium in contact with the solution was much greater. Sketch on your graph the curve or line you would expect from this experiment. Justify the shape and position of your curve or line.

L4. Calculate the average rate of reaction (in g Mg per min) over the first minute of reaction for the two experiments in Exercise L4.

For page 296

M1. On the graph you drew in Exercise L2 draw the curve you would expect for concentration of iodine as a function of time if the experiment were repeated at a temperature about 10 to 20°C higher than that of the original experiment.

M2. For the reaction

$A + B \rightarrow P$

the enthalpy change is 40 kJ/mol and the activation energy is 100 kJ/mol. Draw an energy profile for the reaction. Keep this diagram for Exercise N1 below.

What would be ΔH and E_a for the reverse reaction, $P \rightarrow A + B$?

M3. Some chemists had to react solid calcium hydroxide (slaked lime) with dilute nitric acid to form a solution of calcium nitrate. When they simply added the solid to the solution, the reaction was quite slow. How could they speed it up?

For page 299

N1. Suppose a catalyst were available for the reaction in Exercise M2. On the diagram you drew in that exercise sketch the energy profile you would expect for the catalysed reaction.

N2. The way that ozone is destroyed in the stratosphere is this: ultraviolet light splits off chlorine atoms from chlorine-containing compounds and then

$Cl + O_3 \rightarrow ClO + O_2$

$ClO + O \rightarrow O_2 + Cl$

leading to the overall result, $O_3 + O \rightarrow 2O_2$

Would you consider Cl to be a catalyst for this overall reaction? Explain.

N3. Apart from health considerations why is it important to minimise the amount of flour dust in the air in a flour mill or bread factory?

N4. In catalytic converters on newer motor cars there are two catalysts, rhodium to catalyse

(a) $2NO + 2CO \rightarrow N_2 + 2CO_2$

and platinum to catalyse

(b) $2CO + O_2 \rightarrow 2CO_2$

Platinum also catalyses Hydrocarbon + $O_2 \rightarrow CO_2 + H_2O$

In the design of the converter it is necessary to make reaction (a) considerably faster than (b). Why?

What factor(s) could you vary to control the relative rates of these two reactions?