1 **(a)** The following are two examples of substitution reactions. Only the reaction involving chlorine is a photochemical reaction.

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$

$$CH_4 + Br_2 \rightarrow CH_3Br + HBr$$

(i) Explain the phrase *substitution reaction*.

.....

..... [1]

(ii) How do photochemical reactions differ from other reactions?

.....

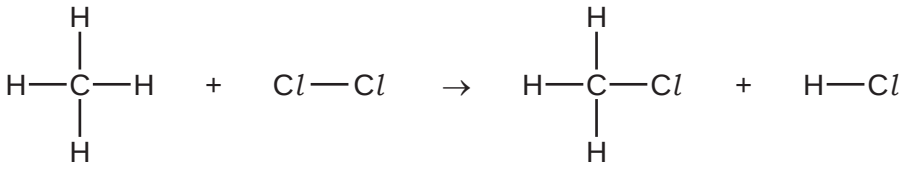
..... [1]

(b) Bond forming is exothermic, bond breaking is endothermic. Explain the difference between an exothermic reaction and an endothermic reaction.

.....

..... [2]

(c) Use the bond energies to show that the following reaction is exothermic.
Bond energy is the amount of energy (kJ / mol) which must be supplied to break one mole of the bond.



Bond energies in kJ / mol

C*l*–C*l*	+242
C–C*l*	+338
C–H	+412
H–C*l*	+431

bonds broken	energy in kJ / mol
.....	.....
.....	.....
total energy =	.....

bonds formed	energy in kJ / mol
.....	.....
.....	.....
total energy =	.....

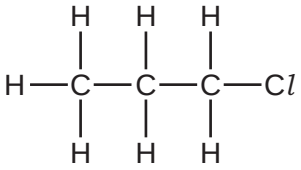
.....

..... [4]

[Total: 8]

2 Many organic compounds which contain a halogen have chloro, bromo or iodo in their name.

(a) The following diagram shows the structure of 1-chloropropane.



(i) Draw the structure of an isomer of this compound.

[1]

(ii) Describe how 1-chloropropane could be made from propane.

.....

..... [2]

(iii) Suggest an explanation why the method you have described in **(ii)** does not produce a pure sample of 1-chloropropane.

.....

..... [2]

(b) Organic halides react with water to form an alcohol and a halide ion.

$$CH_3–CH_2–I + H_2O \rightarrow CH_3–CH_2–OH + I^-$$

(i) Describe how you could show that the reaction mixture contained an iodide ion.

.....

..... [2]

(ii) Name the alcohol formed when 1-chloropropane reacts with water.

..... [1]

(c) The speed (rate) of reaction between an organic halide and water can be measured by the following method.

A mixture of 10 cm^3 of aqueous silver nitrate and 10 cm^3 of ethanol is warmed to 60 °C. Drops of the organic halide are added and the time taken for a precipitate to form is measured.

Silver ions react with the halide ions to form a precipitate of the silver halide.

$$Ag^+(aq) + X^-(aq) \rightarrow AgX(s)$$

Typical results for four experiments, **A**, **B**, **C** and **D**, are given in the table.

experiment	organic halide	number of drops	time / min
A	bromobutane	4	6
B	bromobutane	8	3
C	chlorobutane	4	80
D	iodobutane	4	0.1

(i) Explain why it takes longer to produce a precipitate in experiment **A** than in **B**.

.....

..... [2]

(ii) How does the order of reactivity of the organic halides compare with the order of reactivity of the halogens?

.....

..... [2]

(iii) Explain why the time taken to produce a precipitate would increase if the experiments were repeated at 50 °C.

.....

.....

..... [3]

[Total: 15]

3 A major source of energy is the combustion of fossil fuels.

(a) (i) Name a solid fossil fuel.

..... [1]

(ii) Name a gaseous fossil fuel.

..... [1]

(b) Petroleum is separated into more useful fractions by fractional distillation.

(i) Name **two** liquid fuels obtained from petroleum.

..... and ..... [2]

(ii) Name **two** other useful products obtained from petroleum that are not used as fuels.

..... and ..... [2]

(iii) Give another mixture of liquids that is separated on an industrial scale by fractional distillation.

..... [1]

[Total: 7]

4 The alcohols form a homologous series. The first four members are methanol, ethanol, propan-1-ol and butan-1-ol.

(a) One characteristic of a homologous series is that the physical properties vary in a predictable way. The table below gives the heats of combustion of the first three alcohols.

alcohol	formula	heat of combustion in kJ / mol
methanol	$_3$OH	
ethanol	$_3$-CH_2-OH	
propan-1-ol	$_3$-CH_2-CH_2-OH	
butan-1-ol	$_3$-CH_2-CH_2-CH_2-OH	

(i) The minus sign indicates that there is less chemical energy in the products than in the reactants. What form of energy is given out by the reaction?

.....

[1]

(ii) Is the reaction exothermic or endothermic?

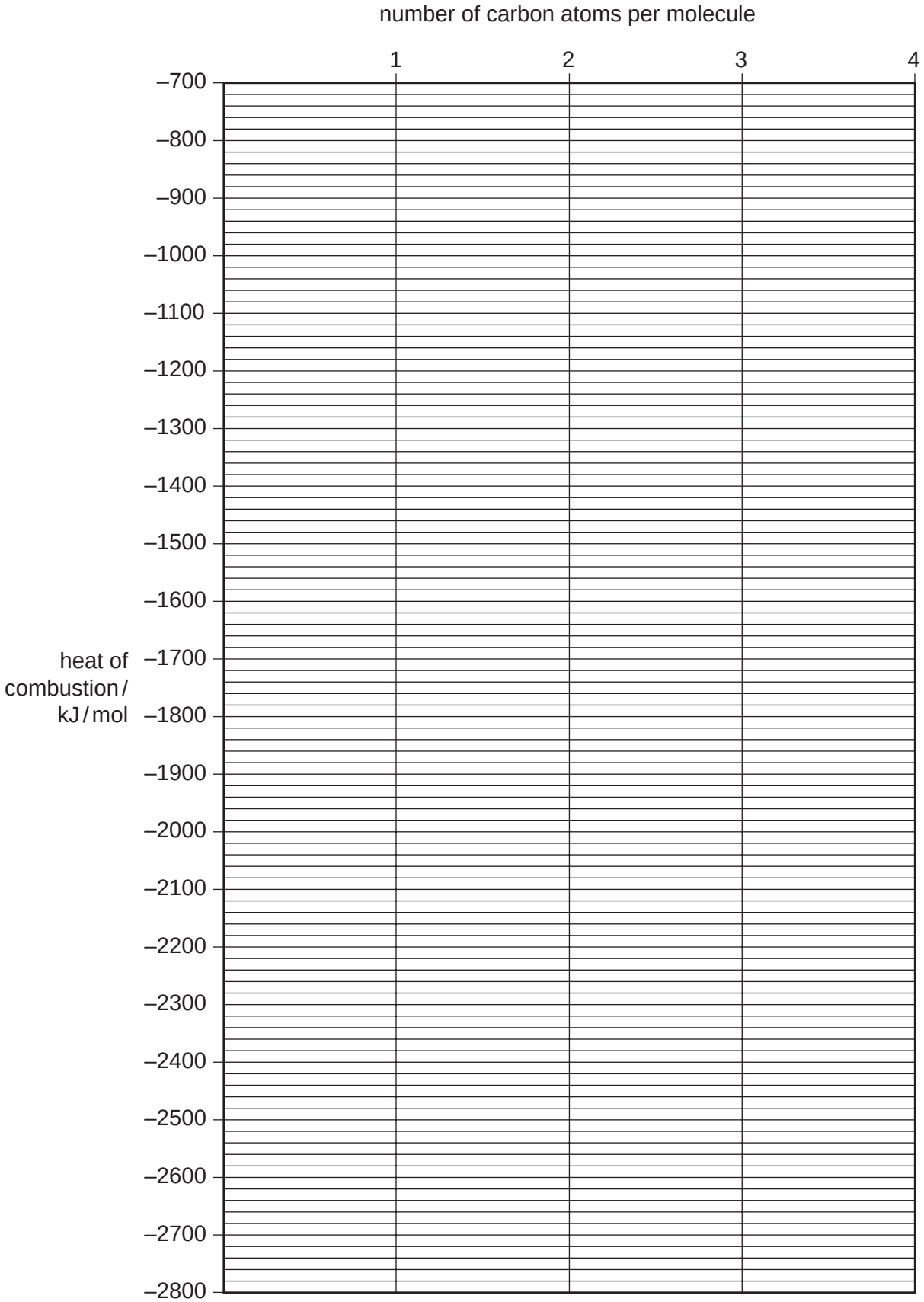
.....

[1]

(iii) Complete the equation for the complete combustion of ethanol.

C_2H_5OH + ... $O_2 \rightarrow$ ..... + ... [2]

(iv) Determine th ombustion of the first three alcohols against the number of carbon atoms per molecule.



The heat of combustion of butan-1-ol = ...kJ / mol [3]

(v) Describe **two** other characteristics of homologous series.

.....

..... [2]

(b) Give the name and structural formula of an isomer of propan-1-ol.
structural formula

name ..... [2]

(c) Methanol is made from carbon monoxide.

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ the forward reaction is exothermic

(i) Describe how hydrogen is obtained from alkanes.

.....

..... [2]

(ii) Suggest a method of making carbon monoxide from methane.

..... [2]

(iii) Which condition, high or low pressure, would give the maximum yield of methanol? Give a reason for your choice.

pressure .....

reason ..... [2]

(d) For each of the following predict the name of the organic product.

(i) reaction between methanol and ethanoic acid

..... [1]

(ii) oxidation of propan-1-ol by potassium dichromate(VI)

..... [1]

(iii) removal of H_2O from ethanol (dehydration)

..... [1]

[Total: 20]