Q1.

This question is about ammonia, NH_3

Ammonia reacts with oxygen in the presence of a metal oxide catalyst to produce nitrogen and water.

(d) Which metal oxide is most likely to be a catalyst for this reaction?

Tick (✓) **one** box.

CaO ☐

Cr_2O_3 ☐

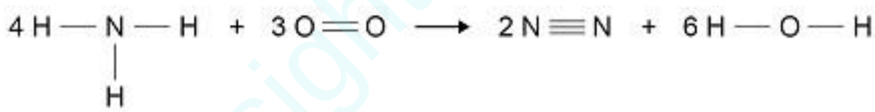
MgO ☐

Na_2O ☐

(1)

Figure 2 shows the displayed formula equation for the reaction.

Figure 2



The table shows some bond energies.

Bond	N — H	O ═ O	N ≡ N	O — H
Bond energy in kJ/mol	391	498	945	464

(e) Calculate the overall energy change for the reaction.

Use **Figure 2** and the table.

Overall energy change = ________________________ kJ/mol

(3)

(f) Explain why the reaction between ammonia and oxygen is exothermic.

Use values from your calculation in part (e).

____

____

____

____

____

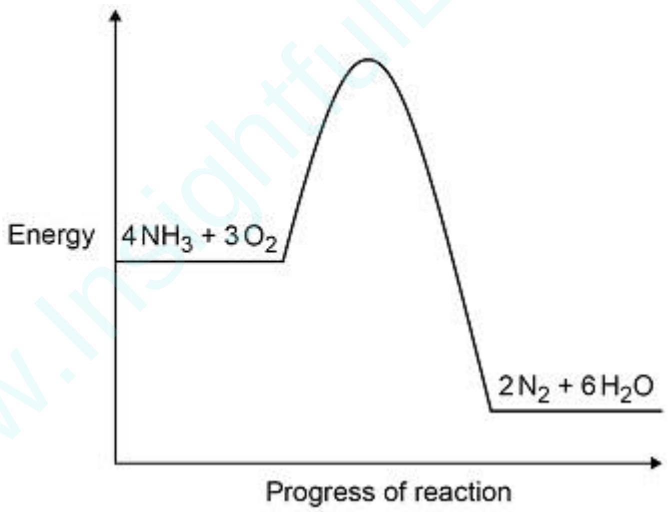
(2)

(g) **Figure 3** shows the reaction profile for the reaction between ammonia and oxygen.

Complete **Figure 3** by labelling the:

- activation energy
- overall energy change.

Figure 3



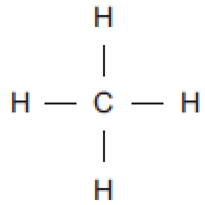
(2)

(Total 14 marks)

Q2.

Methane (CH_4) is used as a fuel.

(a) The displayed structure of methane is:



Draw a ring around a part of the displayed structure that represents a covalent bond.

(1)

(b) Why is methane a compound?

Tick (✓) **one** box.

Methane contains atoms of two elements, combined chemically.	☐
Methane is not in the periodic table.	☐
Methane is a mixture of two different elements.	☐

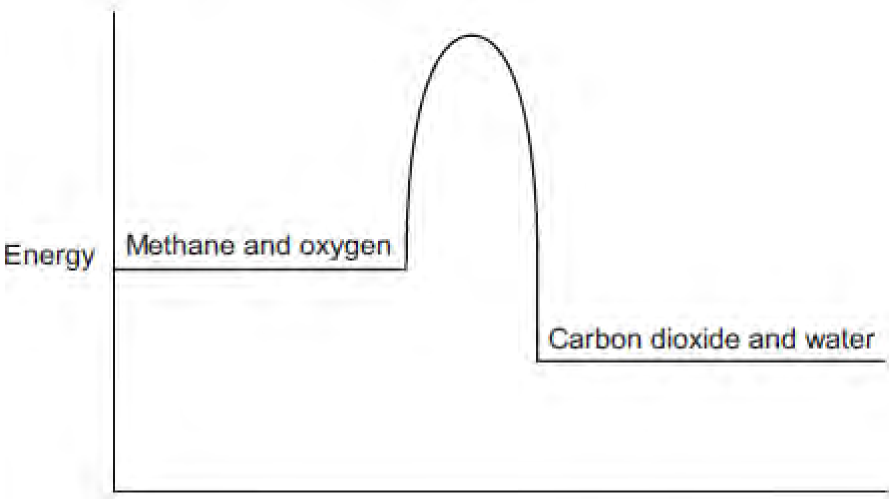
(1)

(c) Methane burns in oxygen.

(i) The diagram below shows the energy level diagram for the complete combustion of methane.

Draw and label arrows on the diagram to show:

- the activation energy
- the enthalpy change, ΔH.



(2)

(ii) Complete and balance the symbol equation for the complete combustion of methane.

$$CH_4 + \_\_\_\_ \longrightarrow CO_2 + \_\_\_\_$$

(2)

(iv) Explain why, in terms of the energy involved in bond breaking and bond making, the combustion of methane is exothermic.

____

____

____

____

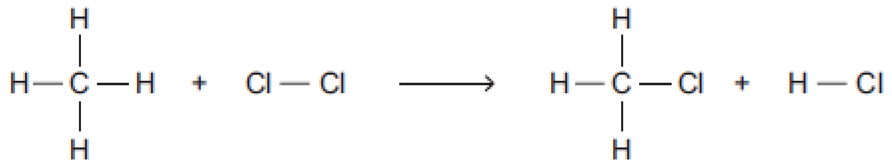
____

____

(3)

(d) Methane reacts with chlorine in the presence of sunlight.

The equation for this reaction is:



Some bond dissociation energies are given in the table.

Bond	**Bond dissociation energy in kJ per mole**
C−H	413
C−Cl	327
Cl−Cl	243
H−Cl	432

(i) Show that the enthalpy change, ΔH, for this reaction is −103 kJ per mole.

____

____

____

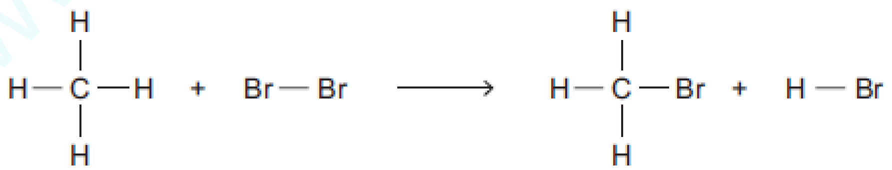
____

____

____

(3)

(ii) Methane also reacts with bromine in the presence of sunlight.



This reaction is less exothermic than the reaction between methane and chlorine.

The enthalpy change, ΔH, is −45 kJ per mole.

What is a possible reason for this?

Tick (✓) **one** box.

CH_3Br has a lower boiling point than CH_3Cl

The C−Br bond is weaker than the C−Cl bond.

The H−Cl bond is weaker than the H−Br bond.

Chlorine is more reactive than bromine.

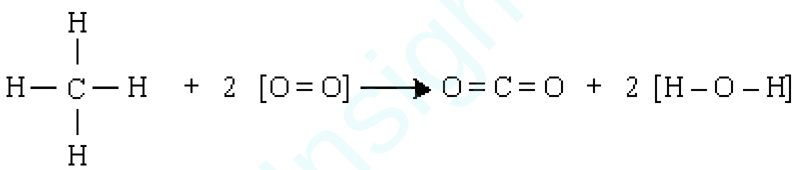
(1)
(Total 15 marks)

Q3.

The symbol equation shows the reaction between methane and oxygen.

CH_4	+	$2O_2$	→	CO_2	+	$2H_2O$
methane		oxygen		carbon dioxide		water

The structural formulae in the equation below show the bonds in each molecule involved.



In the three stages shown at (i), (ii) and (iii) below, calculate the net energy transfer when the formula mass (1 mole) of methane reacts with oxygen.

(i) Write down the bonds broken and the bonds formed during the reaction.

Bonds broken		**Bonds formed**	
number	**type**	**number**	**type**

(4)

(ii) Calculate the total energy changes involved in breaking and in forming each of these bonds.

Total energy change in **Total energy change in**

breaking bonds **forming bonds**

(4)

(iii) Describe, as fully as you can, what the above figures in (ii) tell you about the overall reaction.

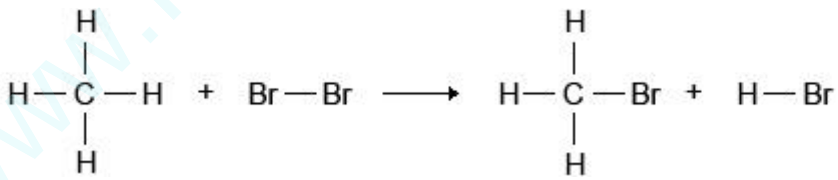
(2)
(Total 10 marks)

Q4.

This question is about Group 7 elements.

(d) Bromine reacts with methane in sunlight.

The diagram below shows the displayed formulae for the reaction of bromine with methane.



The table below shows the bond energies and the overall energy change in the reaction.

	C—H	**Br—Br**	**C—Br**	**H—Br**	**Overall energy change**
Energy in kJ/mol	412	193	**X**	366	−51

Calculate the bond energy **X** for the C—Br bond.

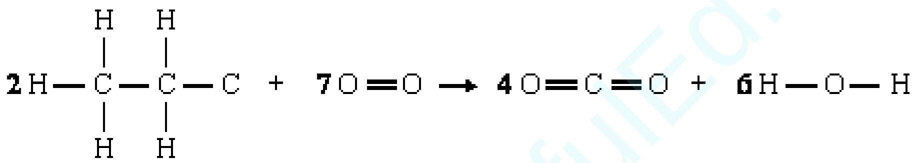
Use the diagram and the table above.

Bond energy **X** = ________________ kJ/mol

(4)

Q5.

The balanced equation for the combustion of ethane is shown using structural formulae.



(a) Complete the table to show the number of bonds broken and made when two molecules of ethane react with seven molecules of oxygen.

Type of bond	Number of bonds broken	Number of bonds made
C — C		
C — H		
O = O		
C = O		
H — O		

(2)

(b) The combustion of ethane is a strongly exothermic process. Draw a labelled energy level diagram showing the endothermic and exothermic parts of the overall reaction. Indicate the activation energy on the diagram.

(4)

(c) Explain, in terms of particles and the activation energy of a reaction, how a catalyst is able to increase the rate of reaction.

(2)
(Total 8 marks)

Q6.

The equation for the reaction of ethene and bromine is:

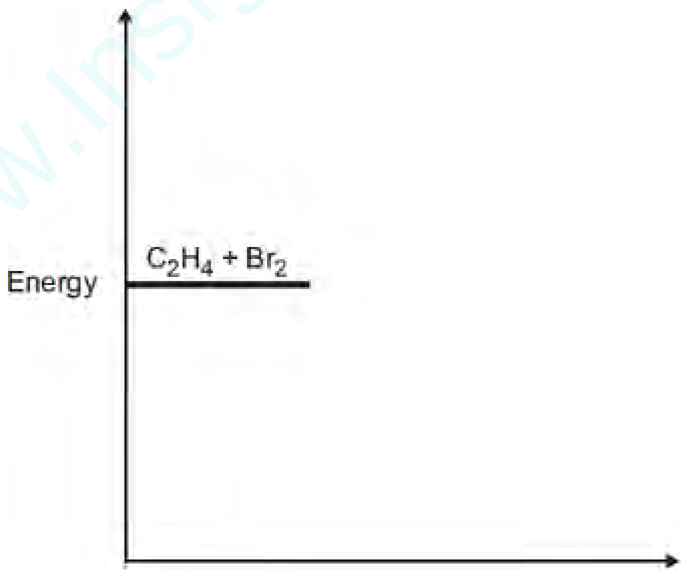
$$C_2H_4(g) + Br_2(l) \longrightarrow C_2H_4Br_2(l)$$

The reaction is exothermic.

(a) Complete the energy level diagram.

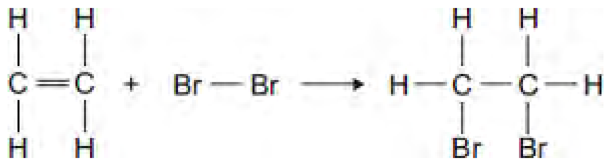
You should label:

- the activation energy
- the enthalpy change (ΔH).



(3)

(b) (i) The equation for the reaction can be represented as:



Bond	Bond dissociation energy in kJ per mole
C—H	413
C = C	614
Br—Br	193
C—C	348
C—Br	276

Use the bond dissociation energies in the table to calculate the enthalpy change (ΔH) for this reaction.

____

____

____

____

____

____

Enthalpy change (ΔH) = ________ kJ per mole

(3)

(ii) The reaction is exothermic.

Explain why, in terms of bonds broken and bonds formed.

____

____

____

____

____

(2)

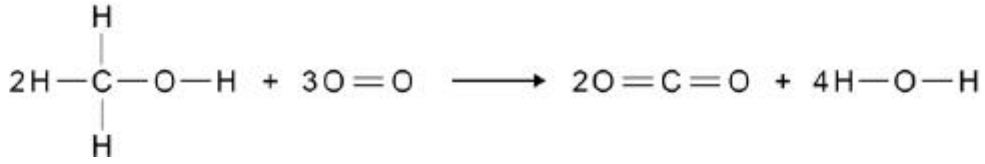
(Total 8 marks)

Q7.

Cells contain chemicals which react to produce electricity.

(e) One type of fuel cell uses methanol instead of hydrogen.

The diagram represents the reaction in this fuel cell.



The table shows the bond energies for the reaction.

	C–H	C–O	O–H	O=O	C=O
Bond energy in kJ / mol	412	360	464	498	805

Calculate the overall energy change for the reaction.

Use the diagram and the table above.

Overall energy change = ____________________ kJ / mol

(3)

(Total 8 marks)

Q8.

Hydrogen chloride is made by reacting hydrogen with chlorine.

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

Bond	Bond energy in kJ
H – H	436
Cl – Cl	242
H – Cl	431

Is the reaction between hydrogen and chlorine exothermic or endothermic?
Use the bond energies to explain your answer.

(Total 3 marks)

Q9.

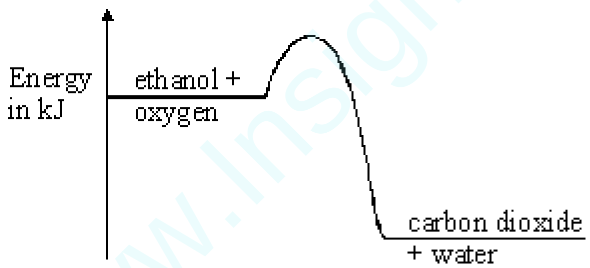
Ethanol is used as a fuel.

(a) Balance the symbol equation for the combustion reaction.

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

(1)

(b) The energy level diagram represents the combustion of ethanol.



Describe what must happen to the molecules of ethanol and oxygen to allow them to react.

(3)

(c) We can use bond energies to calculate the energy change for the reaction between hydrogen and oxygen.

$$2H_2 + O_2 \rightarrow 2H_2O$$

Bond	Bond energy in kJ
H – H	436
O – H	464
O = O	498

(i) Calculate the total bond energy of the reactants.

____

____

____

Total bond energy of reactants = ____________________ kJ

(2)

(ii) Is the reaction between hydrogen and oxygen exothermic or endothermic?
Use bond energies to explain your answer.

____

____

____

____

____

____

____

(2)

(Total 8 marks)

Q10.

Some of the hydrogen and chlorine are reacted together to form hydrogen chloride.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

Bond	Bond energy in kJ/mol
Cl–Cl	242
H–Cl	431

H–H	436

(i) Use the bond energies to calculate the energy change for the formation of hydrogen chloride.

____

____

____

____

Energy change = ____________________ kJ/mol

(3)

(ii) Is this reaction exothermic or endothermic? Explain your answer.

____

____

____

(2)

(iii) Explain why hydrogen chloride only acts as an acid when dissolved in water.

____

____

____

(3)

(Total 8 marks)

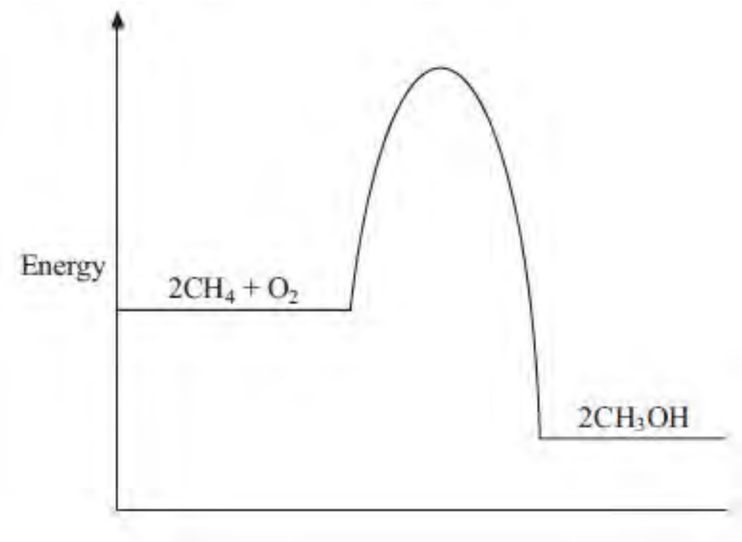
Q11.

Methanol (CH_3OH) can be made by reacting methane (CH_4) and oxygen (O_2) in the presence of a platinum catalyst. The reaction is exothermic.

An equation that represents the reaction is:

$$2CH_4 + O_2 \rightarrow 2CH_3OH$$

(a) The energy level diagram for this reaction is given below.



(i) Use the diagram to explain how you know that this reaction is exothermic.

___

___

___

(1)

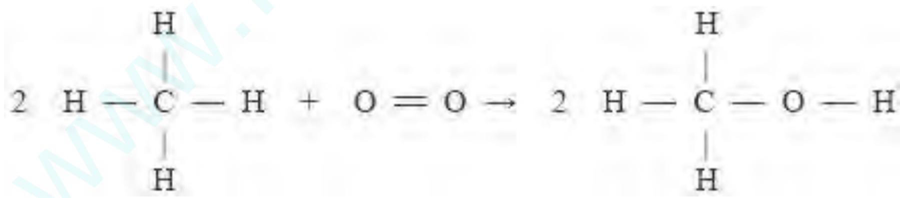
(ii) Explain, in terms of the energy level diagram, how the platinum catalyst increases the rate of this reaction.

___

___

(1)

(b) The equation can also be written showing the structural formulae of the reactants and the product.



(i) Use the bond energies given in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy in kJ
C — H	435
O = O	498
C — O	805

O — H	464

Energy change = ____________________ kJ

(3)

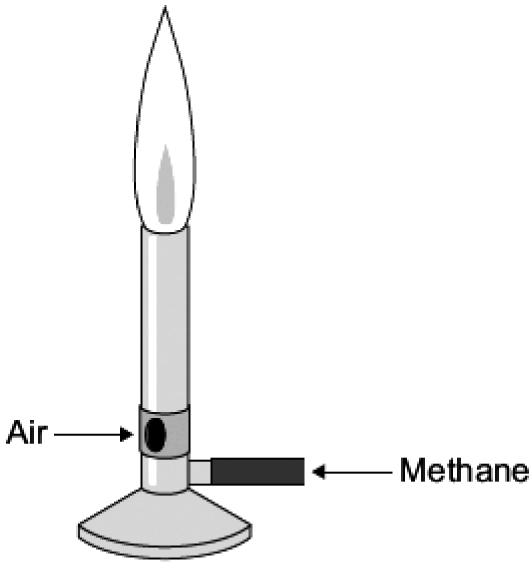
(ii) In terms of the bond energies, explain why this reaction is exothermic.

(1)

(Total 6 marks)

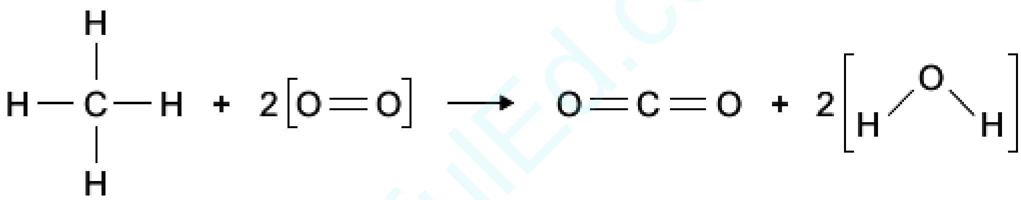
Q12.

A Bunsen burner releases heat energy by burning methane in air.



(a) Methane (CH_4) reacts with oxygen from the air to produce carbon dioxide and water.

(i) Use the equation and the bond energies to calculate a value for the energy change in this reaction.



Bond	Bond energy in kJ per mole
C — H	414
O = O	498
C = O	803
O–H	464

Energy change = ________________ kJ per mole

(3)

(ii) This reaction releases heat energy.

Explain why, in terms of bond energies.

____

____

____

____

(2)

(b) If the gas tap to the Bunsen burner is turned on, the methane does not start burning until it is lit with a match.

Why is heat from the match needed to start the methane burning?

____

____

(1)

(Total 6 marks)

Q13.

Hydrogen peroxide is often used to bleach or lighten hair.

Hydrogen peroxide slowly decomposes to produce water and oxygen.

(a) The equation for the reaction can be represented using structural formulae.

$$2\ H-O-O-H \longrightarrow 2\ H-O-H \quad + \quad O=O$$

Use the bond energies in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy in kJ per mole
H – O	464
O – O	146
O = O	498

____

____

____

____

Energy change = ____________________ kJ

(3)

(b) Explain, in terms of bond making and bond breaking, why the reaction is exothermic.

____

____

____

(1)

(Total 4 marks)

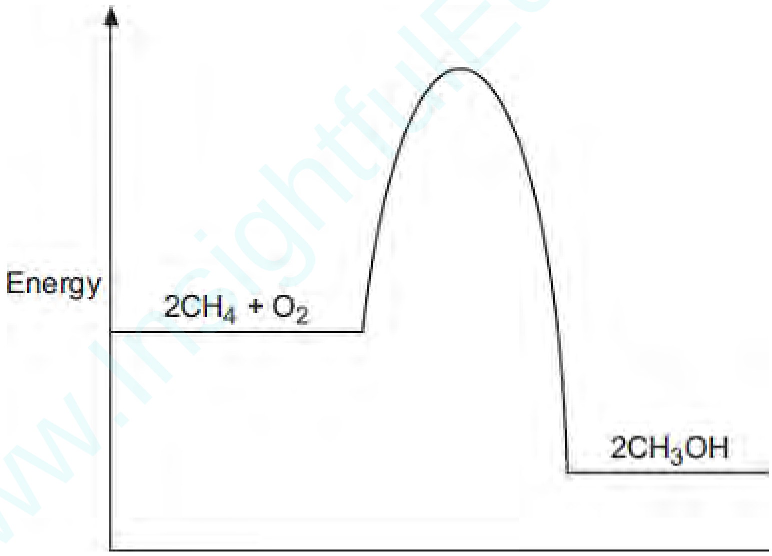
Q14.

Methanol (CH_3OH) can be made by reacting methane (CH_4) and oxygen (O_2).
The reaction is exothermic.

The equation for the reaction is:

$$2CH_4 + O_2 \longrightarrow 2CH_3OH$$

(a) The energy level diagram for this reaction is given below.



(i) How does the diagram show that this reaction is exothermic?

____

____

____

(1)

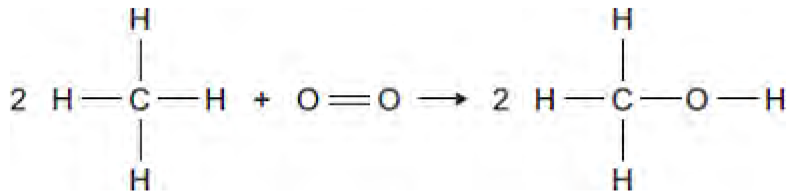
(ii) A platinum catalyst can be used to increase the rate of this reaction.

What effect does adding a catalyst have on the energy level diagram?

____

(1)

(b) The equation can also be written showing the structural formulae of the reactants and the product.



(i) Use the bond energies given in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy in kJ
C—H	435
O═O	497
C—O	336
O—H	464

Energy change = ______________________ kJ

(3)

(iii) In terms of the bond energies, why is this an exothermic reaction?

(1)

(Total 6 marks)

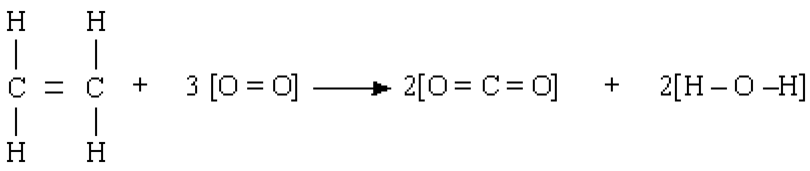
Q15.

You will find the information on the Data Sheet helpful when answering this question.

This equation shows the reaction between ethene and oxygen.

$C_2H_4 \quad + \quad 3O_2 \quad \rightarrow \quad 2CO_2 \quad + \quad 2H_2O$

The structural formulae in the equation below show the bonds in each molecule involved.



Use the three stages shown at (a), (b) and (c) below to calculate the nett energy transfer when the formula mass (1 mole) of ethene reacts with oxygen.

(a) Write down the bonds broken and the bonds formed during the reaction. (Some have already been done for you.)

Bonds broken	
Number	Type
4	[C–H]
1	[C = C]

Bonds formed	
Number	Type
4	[C = O]

(2)

(b) Calculate the total energy changes involved in breaking and in forming all of these bonds. (Some have already been done for you.)

Total energy change in breaking bonds
[4 × 413] = 1652
[1 × 612] = 612
Total = kJ

Total energy change in forming bonds
[4 × [805] = 3220
Total = kJ

(4)

(c) Describe, as fully as you can, what the figures in (b) tell you about the overall reaction.

____

____

____

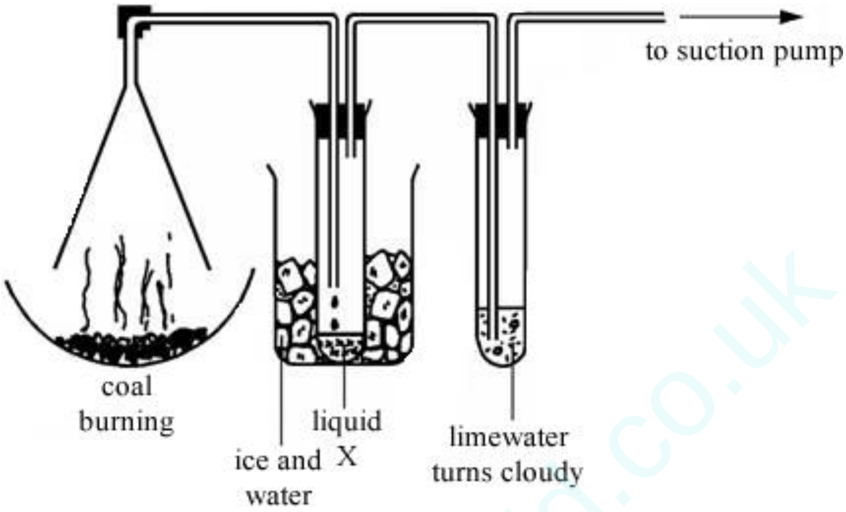
____

____

(2)
(Total 8 marks)

Q16.

The gases produced when coal burns are cooled by ice and then bubbled through limewater.



(a) Complete these sentences.

(i) The coal is reacting with ________________________ when it burns.

(ii) During burning, elements in the coal are converted to compounds

called ______________________________.

(2)

(b) Choose words from this list to complete the sentences.

carbon **carbon dioxide** **sulphur** **sulphur dioxide**

sodium **water**

(i) Liquid X is a compound made from hydrogen and oxygen.

It is called ____

(ii) Sulphur dioxide is an acidic gas. It is given off when coal burns, because coal

contains the element ____

(iii) Most fuels are compounds of hydrogen and __________________________

(3)

(c) Burning coal is an exothermic reaction.

Explain what "exothermic" means.

____

(1)

(d) (i) Which gas turns limewater cloudy?

___

(ii) Which element in the coal is oxidised to form this gas?

___

(2)
(Total 8 marks)

Q17.

This question is about energy changes in chemical reactions.

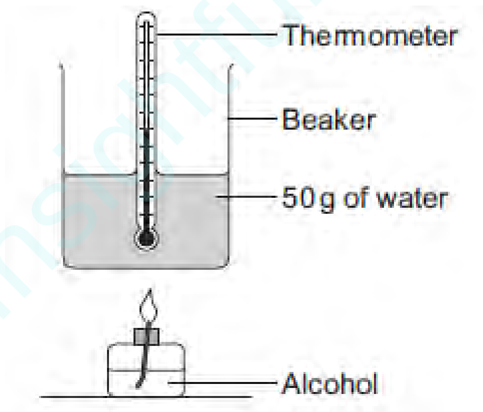
(a) Balance the chemical equation for the combustion of methane.

$$CH_4 \quad + \quad O_2 \quad \longrightarrow \quad CO_2 \quad + \quad H_2O$$

(1)

(b) Alcohols are used as fuels.

A group of students investigated the amount of energy released when an alcohol was burned. The students used the apparatus shown in the diagram below.



In one experiment the temperature of 50 g of water increased from 22.0 °C to 38.4 °C.
The mass of alcohol burned was 0.8 g.

Calculate the heat energy (Q) in joules, released by burning 0.8 g of the alcohol.
Use the equation:

$$Q = m \times c \times \Delta T$$

Specific heat capacity (c) = 4.2 J / g / °C

___

___

___

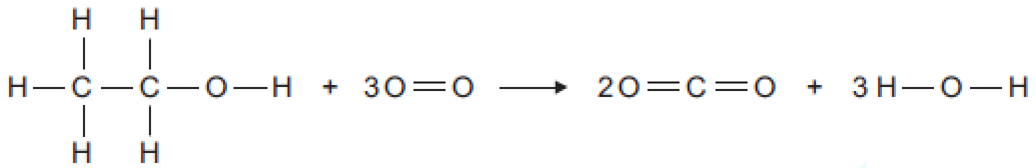
Heat energy (Q) = ____________________ J

(3)

(c) The chemical equation for the combustion of ethanol is:

$$C_2H_5OH \quad + \quad 3O_2 \quad \longrightarrow \quad 2CO_2 \quad + \quad 3H_2O$$

(i) The equation for the reaction can be shown as:



Bond	Bond energy in kJ per mole
C — H	413
C — C	347
C — O	358
C ═ O	799
O — H	467
O ═ O	495

Use the bond energies to calculate the overall energy change for this reaction.

Overall energy change = ____________ kJ per mole

(3)

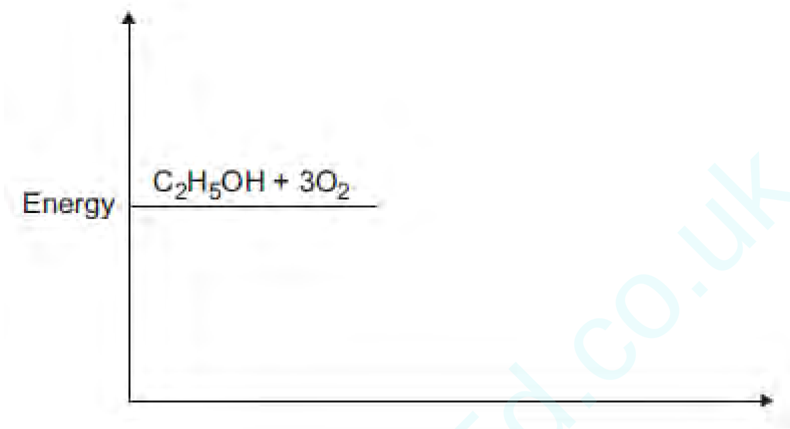
(ii) The reaction is exothermic.
Explain why, in terms of bonds broken and bonds formed.

(2)

(iii) Complete the energy level diagram for the combustion of ethanol.

On the completed diagram, label:

- activation energy
- overall energy change.



(3)

(Total 12 marks)

Q18.

Methane and oxygen react together to produce carbon dioxide and water.

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

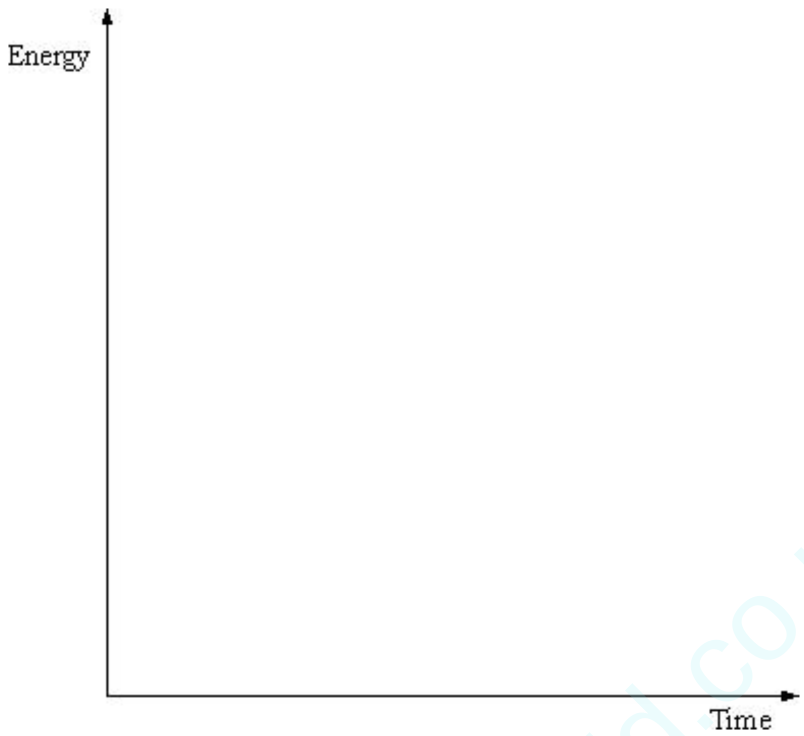
818 kJ of energy is given out to the surroundings for each formula mass (mole) of methane that reacts.

The methane gas will not burn in oxygen until a flame is applied, but once lit it continues to burn.

(a) Explain why energy must be supplied to start the reaction but it continues by itself once started.

(4)

(b) Sketch an energy level diagram for the reaction and indicate on the diagram the nett energy released.



(3)
(Total 7 marks)

Q1.

(d) Cr_2O_3

1

(e)

*an answer of (-)1272 (kJ) scores **3** marks*

(for bonds broken)
((12 x 391) + (3 x 498) =) 6186

1

(for bonds made)
((2 x 945) + (12 x 464) =) 7458

1

(overall energy change = 6186-7458 =) (-)1272 (kJ)

allow correct calculation using incorrectly calculated values from step 1 and/or step 2

1

(f)

allow ecf from part (e)

7458 (kJ) (released in making bonds) is greater than 6186 (kJ) (used in breaking bonds)
or
the products have 1272 (kJ) less energy than the reactants

allow the (overall) energy change is -1272 (kJ)

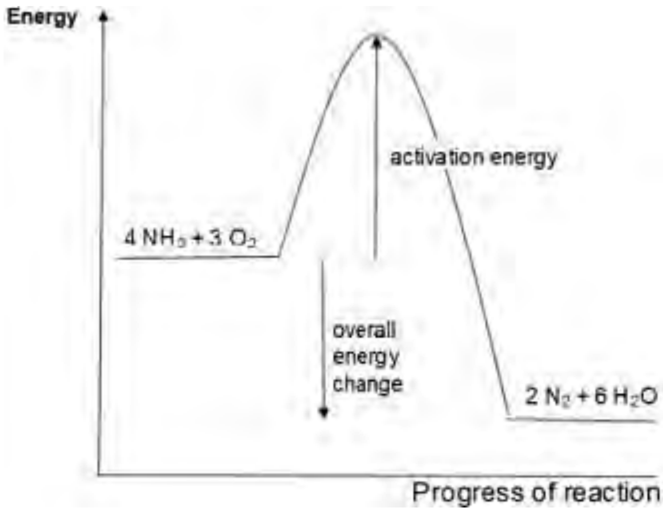
1

(so) energy is released (to the surroundings)

dependent on MP1 being awarded
allow (so) heat is released (to the surroundings)
*if no values given, allow **1** mark for more energy released in making bonds than used in breaking bonds*

1

(g)



*scores **2** marks*

allow discontinuous lines
ignore arrow heads

activation energy labelled 1

(overall) energy change labelled 1

[14]

Q2.

(a) circle round any one (or more) of the covalent bonds

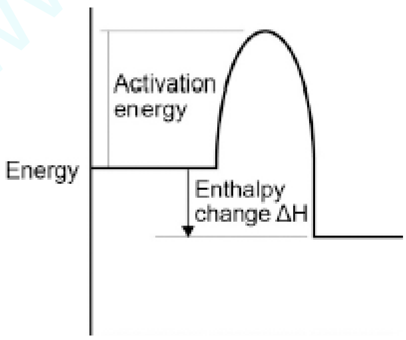
any correct indication of the bond − the line between letters 1

(b) Methane contains atoms of two elements, combined chemically 1

(c) (i) activation energy labelled from level of reagents to highest point of curve

ignore arrowheads 1

enthalpy change labelled from reagents to products



*arrowhead **must** go from reagents to products only* 1

(ii) 2 O_2 1

2 H_2O

*if not fully correct, award **1** mark for all formulae correct.*

ignore state symbols

1

(iv) energy is taken in / required to break bonds

accept bond breaking is endothermic

1

energy is given out when bonds are made

accept bond making is exothermic

1

the energy given out is greater than the energy taken in

this mark only awarded if both of previous marks awarded

1

(d) (i) energy to break bonds = 1895

calculation with no explanation max = 2

1

energy from making bonds = 1998

1

1895 − 1998 (= −103)

or

energy to break bonds = 656

energy from making bonds = 759

656 − 759 (= −103)

allow:

bonds broken − bonds made =

413 + 243 − 327 − 432 = -103 for 3 marks.

1

(ii) The C — Br bond is weaker than the C — Cl bond

1

[15]

Q3.

(i) <u>Bonds broken</u>

4 × (C – H)

2 × (O = O)

each for 1 mark

<u>Bonds formed</u>

2 × (C = O)

4 × (O – H)

each for 1 mark

4

(ii) Total energy change in breaking bonds

(4 × 413) + (2 × 498)

each gains 1 mark

<u>Total energy change in forming bonds</u>

(2 × 805) + (4 × 464)
but
to break bonds = 2648
to form bonds = 3466

each gains 2 marks

4

(iii) nett energy transfer = 818 (kj)
this energy is released in the reaction/is an exothermic reaction
(*credit answers consistent with (ii) or derived from the initial information)*

each for 1 mark

2

[10]

Q4.

(d) (bonds broken = 4(412) + 193 =)1841

1

(bonds formed = 3(412) + 366 + **X** =) 1602 + **X**

1

−51 = 1841 − (1602 + **X**)

allow use of incorrectly calculated values of bonds broken and / or bonds formed from steps 1 and 2 for steps 3 and 4

1

(**X** =) 290 (kJ/mol)

allow a correctly calculated answer from use of −51 = bonds formed − bonds broken

1

OR

alternative method ignoring the 3 unchanged C−H bonds

(412 + 193 =) 605 (1)

366 + **X** (1)

−51 = 605 − (366 + **X**) (1)

(**X** =) 290 (kJ/mol) (1)

*an answer of 290 (kJ/mol) scores **4** marks*

*an answer of 188 (kJ/mol) scores **3** marks*

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

Q5.

(a)

	bonds broken	bonds made
C – C	2 (4)	
C – H	12 (10)	
O = O	7	
C = O		8
H – O		12

1 mark for all bond breaking correct
1 mark for all bond making correct

2

(b) 1 mark for the three energy levels drawn

1

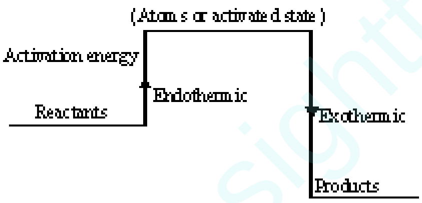
1 mark is for products and reactants labelled, with products shown lower than reactants

1

1 mark for activation energy in the correct position

1

(c) 1 mark (for arrows) and endothermic exothermic labels



arrows not required

1

lowers activation energy

1

more particles have the energy to react
particles do not need as much energy to react

1

[8]

Q6.

(a) products are at a lower energy level than reactants
if candidate has drawn a profile for an endothermic reaction penalise first marking point only

1

activation energy correctly drawn and labelled

1

ΔH correctly labelled 1

(b) (i) –93 (kJ per mole)

*correct answer with or without working gains **3** marks*

*allow **2** marks for +93 kJ per mole*

*if any other answer is seen award up to **2** marks for any two of the steps below:*

*bonds broken (614 + 193) = 807 (kJ) **or** (614 + 193 + (4 × 413)) = 2459(kJ)*

*bonds formed (348 + 276 + 276) = 900(kJ) **or** 348 + (2 × 276) + (4 × 413) = 2552(kJ)*

bonds broken – bonds formed

allow ecf for arithmetical errors 3

(ii) more energy is released when the bonds (in the products) are formed 1

than is needed to break the bonds (in the reactants)

*if no other marks gained, allow **1** mark for energy released for bond making **and** energy used for bond breaking* 1

[8]

Q7.

(e) (bonds broken)

((6 × 412) + (2 × 360) + (2 × 464) + (3 × 498)) = 5614 1

(bonds made)
((4 × 805) + (8 × 464)) = 6932 1

(overall energy change)
(6932 − 5614) = −1318 (kJ / mol)

allow ecf from marking point 1 and / or marking point 2 1

*an answer of 1318 (kJ / mol) scores **3** marks*

Q8.

exothermic does **not** gain any credit 1

reactants: bond breaking (436 + 242 =) 678 (kJ) 1

products: bond making (2 × 431 =) 862(kJ)

so overall 184 (kJ) released / –184(kJ) 1

[3]

Q9.

(a) (1) + 3 → 2 + 3

accept correct multiples 1

(b) any **three** from

- to react particles must collide
- with sufficient energy
- reference to activation energy
- (to cause) bond breaking

3

(c) (i) (436 × 2) + 498 1

= 1370 (kJ)

accept (436 × 2) + 498 ***or*** *934 kJ for one mark*
allow 2 marks for 1370 if no working
or *correct working is shown* 1

(ii) calculation of bond energy or product 1

464 + 464 = 928 × 2 = 1856

incorrect calculation = 0 marks

correct deduction

allow deduction on ecf exothermic / endothermic on own without calculation are neutral 1

[8]

Q10.

(i) 436 + 242 = 678 (kJ) [1]

2 × 431 = 862(kJ) [1]

answer = 184

first ***two*** *marks can be awarded if answer is incorrect*
ignore sign 3

(ii) exothermic 1

more energy released by, bond formation than needed for bond breaking

both parts to be marked depending on answers given in (b)(i) 1

(iii) hydrogen chloride is (a) covalent (compound) 1

when added to water it forms ions **or** H^+ (and Cl^-) 1 hydrogen ions **or** H^+ causes a solution to be acidic

1

[8]

Q11.

(a) (i) energy / heat of products less than energy of reactants

owtte

allow products are lower than reactants

allow more energy / heat given out than taken in

allow methanol is lower

allow converse

allow energy / heat is given out / lost allow ΔH is negative

1

(ii) lowers / less activation energy

owtte

allow lowers energy needed for reaction

***or** it lowers the peak/ maximum*

*do **not** allow just 'lowers the energy'*

1

(b) (i) bonds broken: (2 × 435) + 498 = 1368

allow: (8 × 435) + 498 = 3978

1

bonds made: (2 × 805) + (2 × 464) = 2538

allow: (6 × 435) + (2 × 805) + (2 × 464) = 5148

1

energy change: 1368 – 2538 = (–)1170

allow: 3978 – 5148 = (–)1170

ignore sign

allow ecf

*correct answer (1170) = **3** marks*

1

(ii) energy released forming new bonds is greater than energy needed to break existing bonds owtte

allow converse

*do **not** accept energy needed to form new bonds greater than energy needed to break existing bonds*

1

[6]

Q12.

(a) (i) (-)810

ignore sign

*correct answer gains **3** marks with or without working*

*if the answer is incorrect look at the working up to a maximum of **two***

- *bonds broken = (4 × 414) + (2×498) = 2652 kJ*

- *bonds formed = (2x803) + (4x464) = 3462 kJ*
- *correct subtraction of their bonds formed from their bonds broken*

3

(ii) because energy needed to break the bonds

1

is less than the energy released when bonds are formed

1

(b) to provide <u>activation</u> energy

or

to break bonds

1

[6]

Q13.

(a) *correct answer with or without working = **3** marks*

M1: (bonds broken) = 2148 (kJ)

1

M2: (bonds made) = 2354 (kJ)

1

M3: change in energy
= (-) 206 (kJ)
ecf
ignore sign

1

(b) energy released from forming new bonds is greater than energy needed to break existing bonds
allow the energy needed to break bonds is less than the energy released in forming bonds
*do **not** accept energy needed to form bonds*

1

[4]

Q14.

(a) (i) energy / heat of products less than energy of reactants
allow converse
allow products are lower than reactants
allow more energy / heat given out than taken in
allow methanol is lower
allow energy / heat is given out / lost
allow ΔH is negative

1

(ii) lowers / less activation energy

allow lowers energy needed for reaction
***or** it lowers the peak/ maximum*

*do **not** allow just 'lowers the energy'*

1

(b) (i) (8 × 435) + 497 = 3977

accept: bonds broken: (2 × 435) + 497 = 1367

1

(6 × 435) + (2 × 336) + (2 × 464) = 4210

bonds made: (2 × 336) + (2 × 464) = 1600

1

3977 – 4210 = (–) 233

energy change:

1367 – 1600 = (–) 233

ignore sign

allow ecf

*correct answer (233) = **3** marks with or without working*

1

(ii) energy released forming (new) bonds is greater than energy needed to break (existing) bonds

allow converse

*do **not** accept energy needed to form (new) bonds greater than energy needed to break (existing) bonds*

1

[6]

Q15.

(a)

Bonds broken		Bonds formed	
number	type	number	type
3	[O=O]	4	[O–H]

each for 1 mark

2

(b)

Total energy change in breaking bonds	Total energy change in forming bonds
3 × 498 = 1494	4 × 464 = 1856

each for 1 mark

Total = 3758 Total = 5076

each for 1 mark

4

(c) net energy transfer = 1318
this energy is released in the reaction/it is an exothermic reaction

each for 1 mark

[N.B. credit e.c.f. (a) → (b) <u>and</u> (b) → (c)]

2

[8]

Q16.

(a) (i) oxygen (not air)

(ii) oxides/monoxides/dioxides

for 1 mark each

Do not allow specific examples

2

(b) (i) water

(ii) sulphur

(iii) carbon

for 1 mark each

3

(c) gives out/releases heat/energy

for 1 mark

1

(d) (i) carbon dioxide

(ii) carbon

for 1 mark each

(allow correct symbols/formulae)

2

[8]

Q17.

(a) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

allow multiples

1

(b) 3444 J

if answer incorrect:

one mark for temperature increase = 16.4 °C

one mark for mass of water = 50 g

ecf for one incorrect value gains two marks for correct calculation

no ecf for two incorrect values

3

(c) (i) 1276 (kJ per mole)

ignore + or -

if answer incorrect:

[(5 × 413) + 347 + 358 + 467] + [(3 × 495)] = 4722 (1 mark)

[(4 × 799) + (6 × 467)] = 5998 (1 mark)

correct subtraction of calculated energy values (1 mark)

3

(ii) because energy released when bonds form is greater than energy used when bonds broken *allow converse*

if no mark awarded allow one mark for energy is used to break bonds

or

one mark for energy is released when bonds form

2

(iii) products line lower than reactants

1

activation energy labelled

1

overall energy change labelled

1

[12]

Q18.

(a) *idea that*
existing bonds must <u>first</u> be broken

for 1 mark

(*credit* molecules / atoms more likely to react when they collide)
energy is released when new bonds form

gains 1 mark

but <u>more</u> energy is released when new bonds form

gains 2 marks

or overall reaction exothermic
this breaks more bonds so the reaction continues

for 1 mark

max 4

(b)
- reactant level higher than product level (names of reactants and products not required)
- indication that activation energy required (i.e. the “hump”)
- any correct indication of nett energy change

(i.e. between product and reactant levels even if other marks not gained)

for 1 mark each

3

[7]