Energy changes in chemical and physical processes

1. 6g of Potassium nitrate solid was added to 120cm^3 of water in a plastic beaker. The mixture was stirred gently and the following results were obtained.
   Initial temperature = 21.5^{o}C
   Final temperature = 17.0 ^{o}C
   (a) Calculate the enthalpy change for the reaction
   (Density =1g/cm^3, C= 4.2jg^{-1}K^{-1})
   (b) Calculate the molar enthalpy change for the dissolution of potassium nitrate
   (K=39, N= 14, O =16)

2. (a) The heat of combustion of ethanol, C_2H_5OH is 1370KJ/mole.
   (i) What is meant by heat of combustion?
   (ii) Calculate the heating value of ethanol
   (H = 1.0, C = 12.0, O = 16.0)

3. Use the information below to answer the questions that follow:-
   $Ca_{(s)} + ½\ O_{2(g)}$ $CaO_{(s)}$ ΔH =-635KJ/mol
   $C_{(s)} + O_{2(g)}$ $CO_{2(g)}$ ΔH= -394KJ/mol
   $Ca_{(s)} + C_{(s)} + {}^3/_2O_{2(g)}$ $CaCO_3$ ΔH = -1207KJ/mol
   Calculate the enthalpy change for the reaction:
   $Ca_{(s)} + CO_{2(g)}$ $CaCO_{3(s)}$

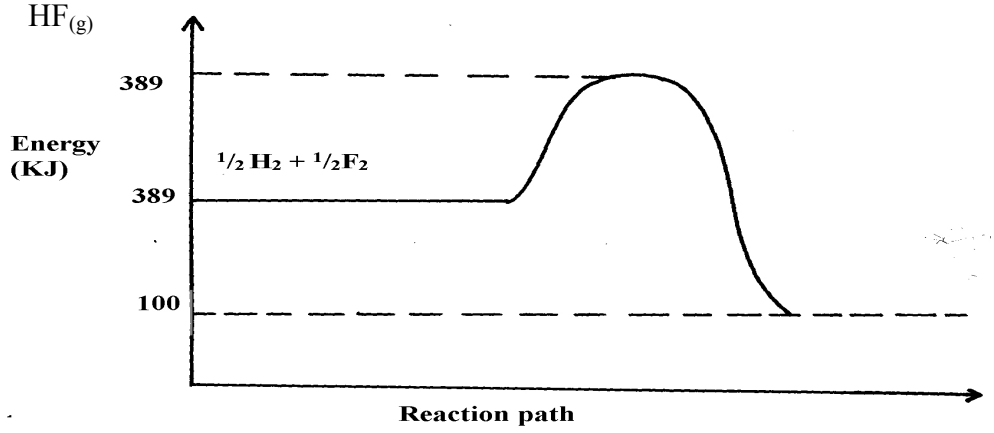
4. 0.92g of ethanol were found to burn in excess air producing a temperature rise of 32.5ºC in 200cm^3 of water.
   C=12.0 H=1.0 O=16.0
   Density of water 1g/cm^3
   Specific heat capacity of water 4.2kj kg^{-1}k^{-1}
   a) Write the equation for combustion of ethanol
   b) Determine the molar heat of combustion of ethanol

5. Study the information in the following table and answer the questions that follow. The letters do not represent the actual chemical symbols of the elements.

ELEMENT	**U**	**V**	**W**	**X**	**Y**	**Z**
NUMBER OF PROTONS	18	20	6	16	19	17
NUMBER OF NEUTRONS	22	20	8	16	20	20

   Which of the above elements are:
   (i) Likely to be radioactive?
   (ii) Able to form a compound with the highest ionic character?

6. The diagram below shows energy levels for the reaction
   ½ $H_{2(g)}$ + ½ $F_{2(g)}$ $HF_{(g)}$



   (a) Work out the activation energy for the reaction

(b) Calculate the heat of formation of **HF**

(c) Is the reaction endothermic or exothermic?

7. Using the heats of combustion of the following substances, calculate the heat of formation of ethanol

$C_{(s)} + O_{2\,(g)} \rightarrow CO_{2\,(g)}$; $\Delta H = -393 KJmol^{-1}$

$H_{2\,(g)} + ½\ O_{2\,(g)} \rightarrow H_2O_{(l)}$; $\Delta H = -286 KJmol^{-1}$

$CH_3CH_2OH_{(l)} + O_{2\,(g)} \rightarrow 2CO_{2\,(g)} + 3H_2O_{\,(l)}$; $\Delta H = 1386 KJmol^{-1}$

8. Nitrogen and hydrogen react reversibly according to the equation:-

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g);}$ $_{\Delta}H = -92 kjmol^{-1}$

The energy level diagram for the above reaction is shown below:-

(a) How would the yield of ammonia be affected by:

(i) A decrease in temperature

(ii) An increase in pressure

(b) How does a catalyst affect reversible reaction already in equilibrium?

(c) On the above diagram, sketch the energy level diagram that would be obtained when iron catalyst is added to the reaction

9. Study the table below and answer the questions that follow

Bond type	**bond energy $kJmol^{-1}$**
C-C	346
C = C	610
C-H	413
C-Br	280
Br-Br	193

a) Calculate the enthalpy change for the following reaction

$C_2H_{4(g)} + Br_{2(g)} \rightarrow C_2H_4Br_{2(g)}$

b) Name the type of reaction that took place in **(a)** above

1 mark

10. Bond energies for some bonds are tabulated below:-

BOND	**BOND ENERGY KJ/mol**
H – H	436
C = C	610
C- H	410
C - C	345

Use the bond energies to estimate the enthalpy for the reaction

$C_2H_{4(g)} + H_{2(g)} \quad C_2H_{6(g)}$

11. The able shows the results obtained when 20.2g of potassium nitrate was added in $50cm^3$ of water.

Time in (min)	0.0	0.3	1.0	1.3	2.0	2.3	3.0	3.3	4.0
Temperature (^oC)	25.0	25.0	25.0	25.0	17.0	17.0	20.0	20.0	20.0

(i) Draw the graph of temperature against time

(ii) Using the graph, determine the temperature change

(iii) Calculate the heat change

(iv) Find the molar heat of solution of potassium nitrate

12. When 1.6g of ammonium nitrate were dissolved in $100cm^3$ of water, the temperature dropped by 6ºC. Calculate its enthalpy change. (Density of water = $1g/cm^3$, specific heat capacity is $4.2kJ\ kg^{-1}K^{-1}$)

13. Sodium hydrogen carbonate was strongly heated.

a) Write an equation for the reaction

b) The grid below shows part of the periodic table. Use it to answer the questions that follow. The letters are not the actual symbols.

i) Write the equation for the reaction that occurs between elements **L** and **D**

ii) The oxide of **G** reacts with both hydrochloric acid and sodium hydroxide. What is the nature of the oxide of **G**?

iii) Explain why elements **H** has a higher boiling points than element **D**.

iv) State **one** use of element **E**

v) Compare and explain the atomic radius of **B** and **C**

vi) 11.5g of **L was** completely burnt in oxygen .Calculate the volume of gas that was used. (L = 23, molar gas volume at room temperature is $24dm^3$)

14. A student has been provided with sodium hydroxide solution of 2M and hydrobromic acid of 4M. He was asked to investigate the equation for the reaction between these two substances and hence determine the molar enthalpy of neutralization. He carried out the reaction and obtained the following results:-

Vol. of 4M Hydrobromic acid added to $20cm^3$ of 2M NaOH	**Temperature of the mixture (^oC)**
4.0	26.8
6.0	30.0
8.0	33.2
10.0	36.0
12.0	35.2
14.0	34.4
20.0	30.8

(a) Draw a graph of the temperature of the mixture (vertical axis against the volume of the

acid added) *

(b) Using the graph estimate the temperature of the mixture when 17cm^3 of the acid was added

(c) Both solutions were at room temperature at the start of the experiment. Use your graph to estimate the room temperature (½mk)

(d) What is the significance of the highest temperature of the solution mixture? *

(e) The temperature of the mixture increased during the first additions of the acid. Why did the temperature increase? *

(f) Suggest a reason why the temperature decreased during the latter part of the experiment

(g) Use your graph to determine the volume of 4M Hydrobromic acid which just neutralize 20cm^3 of 2M NaOH *

(h) How many moles of Hydrobromic acid are present in your answer in (**g**) above? *

(i) How many moles of NaOH are present in 20cm^3 of 2M of NaOH solution? *

(j) Use your answers in (**h**) and **(i**) above to write an equation of the reaction taking place in the experiment. Explain clearly how you have used your answers (1½mks)

(k) Determine the molar enthalpy of neutralization of hydrobromic acid (1½mks)

15. (a) The following results were obtained in an experiment to determine the enthalpy of solution of sodium hydroxide

Mass of plastic beaker = 8.0g

Mass of plastic beaker + distilled water = 108.15g

Mass of plastic beaker + distilled water + sodium hydroxide = 114.35g

The table below shows the temperature at fixed times after mixing

Time/seconds	0	30	60	90	120	150	180	210
Temperature (^oC)	15	21	29	28	27	26	26	25

(i) Plot a graph of temperature (y-axis) against time (x-axis)

(ii) From your graph, determine the maximum temperature attained

(iii) Determine the temperature change of the reaction

(iv) Calculate the number of moles of sodium hydroxide used in the experiment (Na = 11, H = 1, O = 16)

(v) Use your results to determine the molar enthalpy solution of sodium hydroxide. (Density of solution is 1g cm^{-3} , specific heat capacity of solution = 4.18 $KJ^{-1}K^{-1}$)

(b) Below is an energy level diagram of the exothermic reaction

$CH_{4(g)} + 2O_{2(g)}$ $CO_{2(g)} + 2H_2O_{(l)}$ $\Delta H = -890KJ$

Examine the energy level diagram below and use it to answer the questions that follow

(b) (i) Which ΔH values will have negative sign?

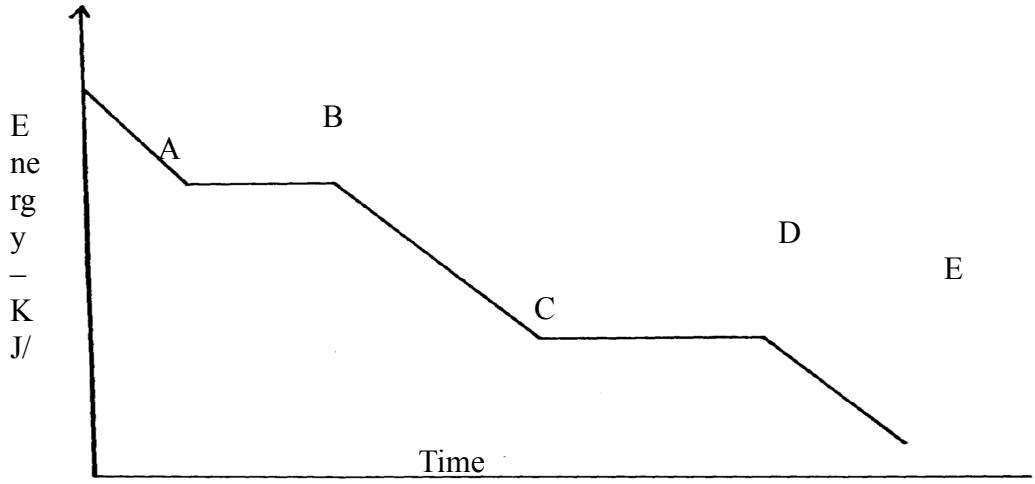
(ii) What physical change is being represented where enthalpy change ΔH_4 is involved? (½mk)

(iii) In terms of ΔH_1, ΔH_2, ΔH_3 and ΔH_4, give the overall enthalpy change for the reaction:-

$H_{2(g)} + ½\ O_{2(g)}$ $H_2O_{(l)}$

(iv) Is the reaction in **(iii)** above exothermic or endothermic?

16. (I) Study the graph below and answer the questions which follow:



(a) Distinguish between molar latent heat of fusion and molar latent heat of vaporization

(b) (i) Explain the changes occurring between points

BC …… **CD** ……

(ii) In an experiment to determine molar enthalpy of neutralization of hydrochloric acid using potassium hydroxide, the data below was obtained. The concentration of potassium hydroxide used was 0.5M

Volume of 0.5M KOH (cm^3)	0	5	10	15	20	25	30	35
Total volume of acid + Base	20	25	30	35	40	45	50	55
Temperature (^oC)	24	26	27	28	29	29	28	27

(i) Plot a graph of temperature (y-axis) against volume of potassium hydroxide used

(ii) From your graph:

(a) Determine the temperature change

(b) Find the volume of potassium hydroxide which completely neutralized $20cm^3$ of the acid

(iii) Calculate the heat change for the reaction ($C = 4.2Jg^{-1}K^{-1}$ density of solution = $1g/dm^3$)

(iv) Calculate the molar enthalpy of neutralization of hydrochloric acid with potassium hydroxide

17. A typical electrolysis cell uses a current of 40,000 amperes. Calculate the mass (in Kg of aluminium produced in one hour). (Al = 27) (Faraday = 96500Coloumbs)

18. (a) Biogas is a mixture of mainly Carbon (IV) Oxide and methane.
(i) Give a reason why biogas can be used as a fuel
(ii) Other than fractional distillation, describe a method that can be used to determine the percentage of methane in biogas

19. Consider the following equilibrium reaction.
$H_2(g) + Cl_2(g)$ $2HCl(g)$ $\Delta H = -74.4KJ$
a) State and explain the effect of formation of hydrogen chloride if pressure was increased in the equation above

20. Turning of fossil fuels has adverse environmental effects:-
a) Name **two** pollutants from the burning of petroleum products
b) Give **one** precaution taken to minimise the pollution by fossil fuels

21. (a) Define molar heat of neutralization
(b) The rise in temperature when $50cm^3$ of sodium hydroxide is reacted with two acids is given in the table below:-

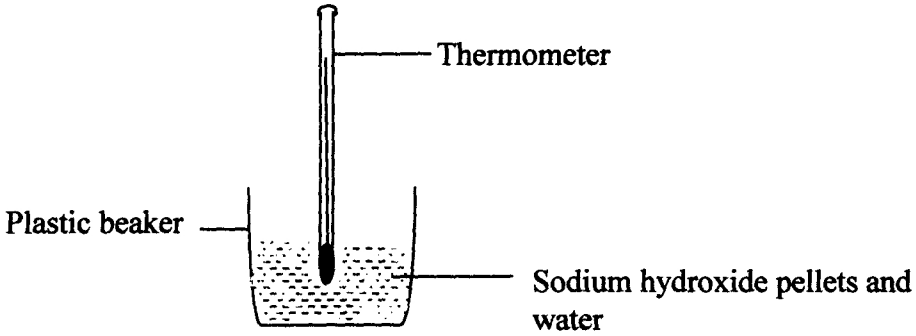
Acid	**$50cm^3$ of HCl**	**50cm of Oxalic acid**
Temp rise (^oC)	7	4

(i) Explain the difference in the temperature.

22. Calculate the latent heat of vaporization of water
$H_2O_{(l)}$ $H_2O_{(g)}$
Given the following thermo chemical equations:-
$H_{2(g)} + \frac{1}{2}O_{2(g)}$ $H_2O_{(g)}$ $\Delta H^{\theta} = -242KJ/Mol$
$H_{2(g)} + \frac{1}{2}O_{2(g)}$ $H_2O_{(l)}$ $\Delta H^{\theta} = -286KJ/Mol$

23. (a) Define the term fuel
(b) State **four** reasons why wood fuel is chosen for domestic cooking

24. The setup bellow was used to investigate the changes that take place when sodium hydroxide pellets dissolve in water.



a) Why is a plastic beaker used instead of a metallic beaker?
b) State and explain the observations made in the above reaction

25. (a) What is a fuel? (1mark)
(b)Other than the cost, state **two** other factors to consider when choosing a fuel.

26. The equation below represents changes in the physical state of ions metal:
$Fe_{(s)}$ $Fe_{(l)}$ $DH = +15.4kjmol^{-1}$
$Fe_{(l)}$ $Fe_{(g)}$ $DH = +354kjmol^{-1}$
a) Calculate the amount of heat energy required to change 10kg of solid iron to gaseous iron
Fe = 56

b) Iodine can react with chlorine as shown below:-

$I_{2(g)} + Cl_{(g)}$ $2lcl_{(s)}$ DH= -68kJ

Determine the molar enthalpy change for this reaction

c) Draw an energy level diagram for the reaction in **(b)** above

27. Study the diagram below and answer the questions that follow:

Reaction Co-ordinate

a) What do ΔH_1 and ΔH_2 represent?
ΔH_1 …….
ΔH_2 ……..
b) Write an expression to show the relationship between ΔH_1, ΔH_2 and ΔH_3.