Friday worksheet 12 – Enthalpy, energy diagrams and experimental technique.

1) A hiker suggested that the higher the altitude the less energy required to heat a given mass of water by 10°C.
A student performed the experiment at three different altitudes using a butane gas bottle. A small spring balance was used to measure masses. A hand held alcohol thermometer was used to record temperature.
The results are provided in the table below.

	Trial 1	Trial 2	Trial 3
Altitude above sea level(metres)	10	880	2500
Air pressure (Kpa)	101	85	79
Air temperature (°C)	13.0	12.0	5.0
Mass of butane bottle before burning	1.200 kg	1.700 kg	1.200 g
Mass of butane bottle after burning	1.999 kg	1.650 kg	1.001 g
Initial temperature of 100 grams of water (°C)	9.01	5.02	1.00
Final temperature of 100 grams of water (°C)	19.54	15.10	11.02
Shape of aluminium container to house the water			

i. Calculate the theoretical amount of energy obtained from the combustion of butane in trial 3.
Step 1 calculate the mass of butane burnt.
=> (1.200g -1.001g) = 0.199g
Step 2 calculate the theoretical amount of energy given off.
=> 0.199 X 49.7 (from Data Book) = 9.89 kJ

ii. What percentage of the energy given out by the butane actually went into heating the water?
Step 1 find the amount of energy that went into the water.
=> E(J) = 4.18 X 100 X 10.02 = 4.19kJ
Step 2 find the percentage
=> (4.19 / 9.89) X 100 = 42.4%

iii. What is the experimental heat of combustion of butane in kJ/g from the data collected in trial 3.

=> 4.19 kJ / 0.199g = 21.1kJ/g

iv. State a possible hypothesis

If the altitude at which a body of water is heated increases then less energy is required to raise its temperature by 10°C

v. Are the results provided valid? Explain

A valid experiment is a fair test hence a method is valid if:

• it tests the hypothesis with an appropriate range of values for the independent variable.

• it incorporates suitable equipment (e.g. measuring cylinder to measure volume rather than a beaker or digital balance as opposed to a spring balance)

• all other variables apart from the independent variable are controlled

• appropriate measuring procedures are included

The experimental procedure, above, has many flaws and hence cannot be termed valid. Not all variables are controlled such as, type of cup, material of cup, temperature of the air. Measuring devices such as a spring balance are not accurate enough to detect small changes in mass. Nor is the ethanol thermometer precise enough to measure small temperature changes to the degree of accuracy stated in the table above.

vi. What can you say about the reliability of this experiment?

A reliable experiment has results which can be obtained consistently. To ensure that results are reliable:

• the experiment must be repeated and consistent results obtained (within an acceptable margin of error)

Note: Repetition will only determine reliability but will not improve it.

A useful analogy is that of an ambulance arriving within 10 minutes of an 000 call. If it arrives on time once only, it can't be said that it is reliable, but if it arrives late several times, then it can be said that it is unreliable. By simply timing the ambulance repeatedly doesn't make it reliable.

In discussing reliability we must :

• identify that reliability is <u>assessed</u> by repeating the experiment and averaging the results

• identify that repetition minimises the effect of random errors/outliers and/or allows them to be removed or disregarded

• give examples of possible random errors that may have crept into the experiment you are considering

Since each trial at a given altitude was not repeated we can say that the results are unreliable. Repeating the experiment more than once at a given altitude should tell us if the experiment is reliable or not but will not improve the reliability. Identifying and removing random errors should make the results more reliable and this comes back to the validity of the experiment.

In the experiment above identifying random errors may include:
- wind that may remove energy form entering he water
- the tension of the spring balance at different temperatures

It is possible for some measurements and observations to be reliable without being valid. For example, a faulty spring balance can consistently provide a wrong value therefore providing reliably incorrect measurements, however, measurements and observations cannot be valid unless they are reliable and accurate.

2) Consider the reaction below.
$c_2(g) + 2X(g) \rightarrow 2CX(l)$ $\Delta H = ?$ *kJ/mol*
i. Draw the energy profile diagram in the set of axes provided on the right if the energy required to break bonds of the reactant particles is 22.1kJ/mol while 45.2 kJ/mol of energy is given out during bond formation.
Indicate the following on the diagram.
Activation energy and ΔH
ii. On the same set of axes draw the energy profile diagram of the reaction below.
$c_2(g) + 2X(g) \rightarrow 2CX(g)$ $\Delta H = ?$ *kJ/mol*
No specific value for ΔH need be given.
$c_2(g) + 2X(g) \rightarrow 2CX(g)$ $\Delta H = ?$ kJ/mol is In blue
The ΔH is lower than the) ΔH of the reaction
$c_2(g) + 2X(g) \rightarrow 2CX(l)$ as the products are in gaseous form and need more energy to maintain this state, hence less energy is given out to the environment.