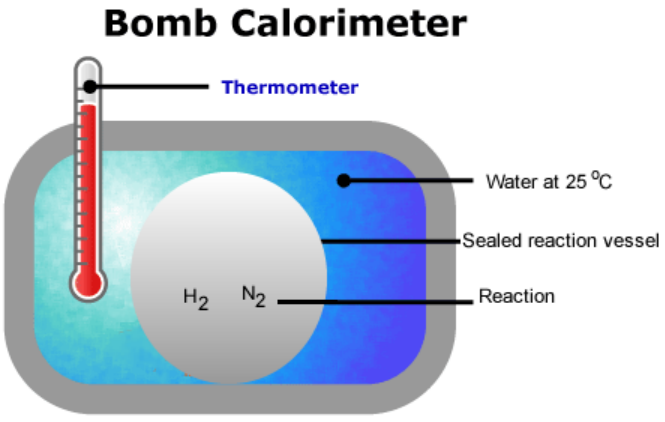
Friday Worksheet **Name: ……**

Enthalpy and rate worksheet

1) The Haber process is important for the industrial production of ammonia. The equation for this reaction is given below.

$$N_2(g) + 3H_2(g) \leftrightarrows 2NH_3(g) \qquad \Delta H = -91 \text{ kJ.mol}^{-1}$$

3.90 g of N_2 gas and 0.800 g of H_2 gas react according to the equation above.



The process uses an iron catalyst.

a) Calculate the number of mol of each reactant present.

b) Identify the limiting reagent.

c) Calculate the amount of excess reagent

d) Will the temperature of the water rise or fall? Explain.

e) What amount of energy, in kJ, is given out by the reaction?

f) Explain the impact of using a catalyst under the following headings.

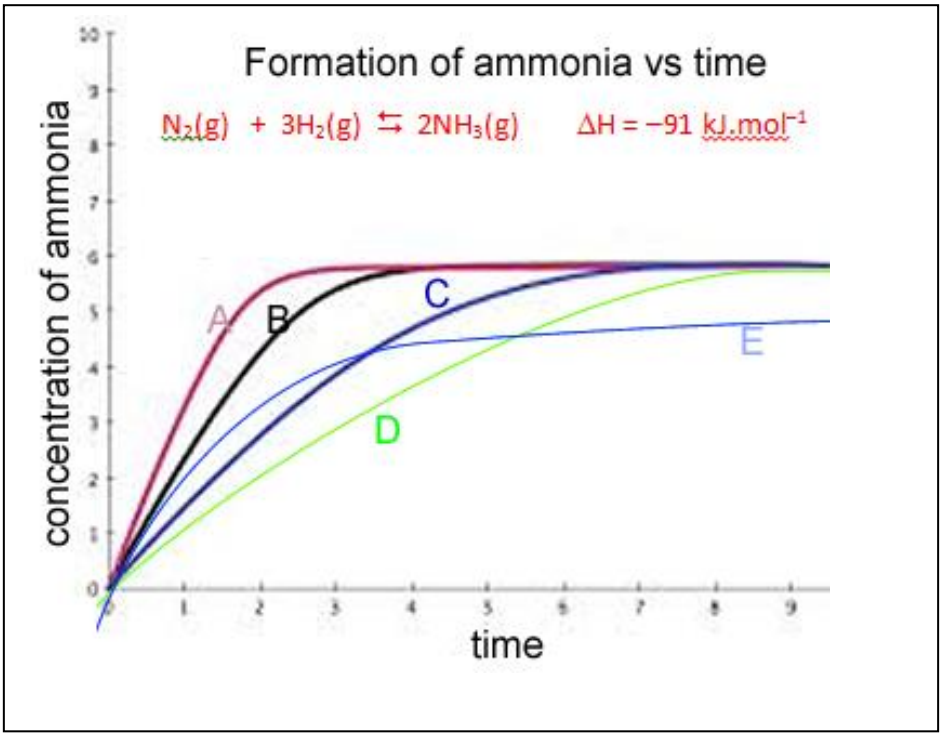
How does a catalyst impact on the:

i) number and type of collisions taking place between reactant particles per second,

ii) total amount of heat given out by the reaction,

iii) forward and backward rates of the reaction once equilibrium is achieved,

g) The reaction is conducted five different times. Each time the reaction is conducted only one variable is modified and the amount of ammonia formed measured against time. Graph C represent the reaction at 25 ^{o}C in the absence of an iron catalyst.



Indicate which graph is consistent with the following conditions. Explain your choice

i. The use of a solid iron catalyst.

ii. The use of a powdered iron catalyst.

iii. The reaction taking place at 8 ^{o}C, in the absence of a catalyst.

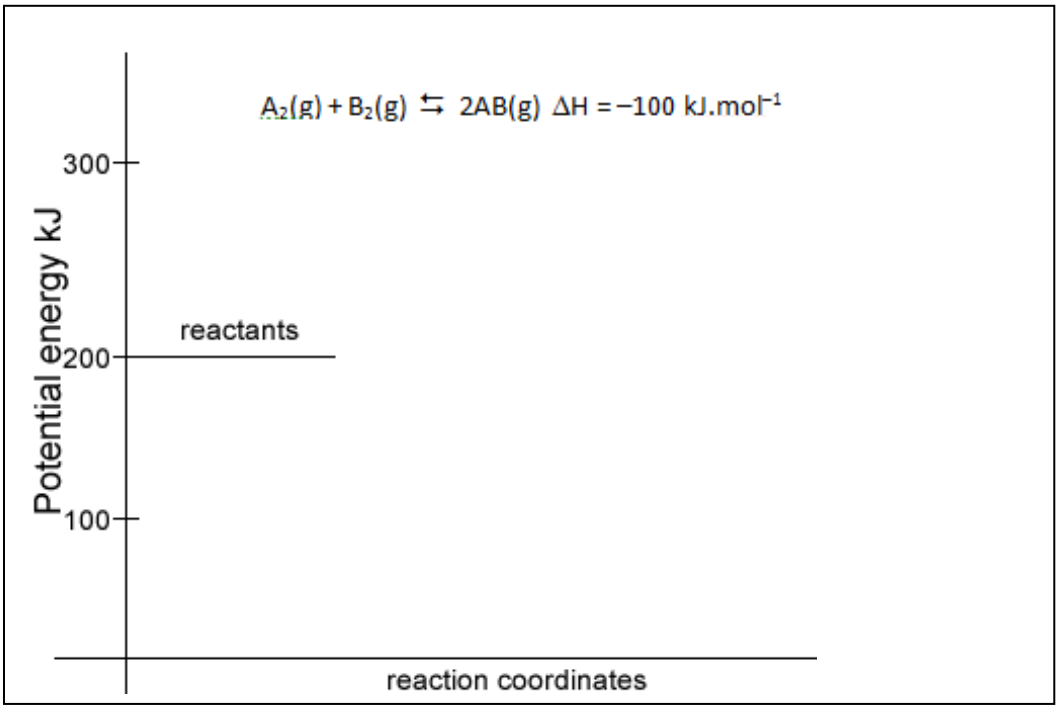
iv. The reaction taking place at 500 ^{o}C

h) One mole of reactant A_2 reacted with one mole of reactant B_2 according to the equation below.

$$A_2(g) + B_2(g) \leftrightarrows 2AB(g) \quad \Delta H = -100 \text{ kJ.mol}^{-1}$$

It required 80 kJ of energy to break the bonds of the reactants.

i. Draw an energy profile for the reaction above on the set of axes below.



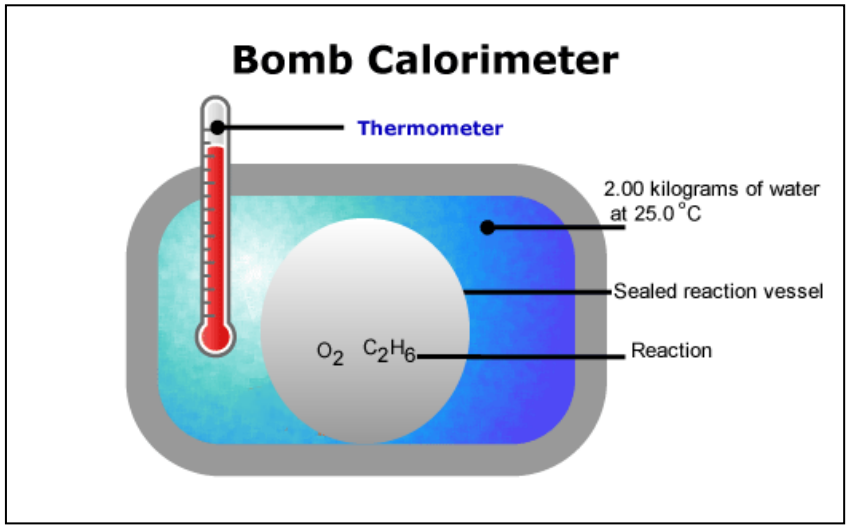
ii. The same reaction was conducted in the presence of a catalyst. Draw the energy profile on the same set of axes above.

iii. The two reactions below are conducted under the same conditions.
$A_2(g) + B_2(g) \leftrightarrows 2AB(g)$ and
$2AB(g) \leftrightarrows A_2(g) + B_2(g)$
What can you say about the rates of the two reactions below?

2) Ethane burns in oxygen according to the equation below

$$2C_2H_6(g) + 7O_2(g) \rightarrow 6H_2O(g) + 4CO_2(g)$$

A sample of 32.10 grams of oxygen is placed in a sealed container, as shown below, with excess ethane and ignited. The temperature of the water reached a maximum of 78.5 °C.



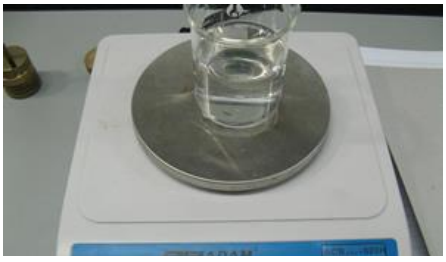
a) Calculate the mol of ethane that reacted.

b) Calculate the amount of energy released, assuming no energy is lost from the system, using the information given in the question above.

c) Calculate the ΔH for the equation $2C_2H_6(g) + 7O_2(g) \rightarrow 6H_2O(g) + 4CO_2(g)$

3) Hydrogen peroxide decomposes to form oxygen gas and water, according to the equation below.

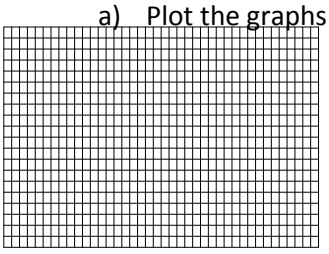
$$2H_2O_2(aq) \Rightarrow 2\ H_2O(l) + O_2(g)$$



In an investigation to measure the rate of decomposition of H_2O_2 was conducted by a student who set up the following experiment. He set up four beakers containing 100 mL of 30% v/v of H_2O_2 each. Beaker A was kept at 10 ^oC, while beaker B was kept at 20 ^oC, beaker C at 60 ^oC and beaker D at 90 ^oC. To start the reaction, a small amount of potassium iodide was placed in each beaker, the amount varied from beaker to beaker. The student recorded the following data for mass loss in grams (measured from the total starting mass) and the time, in seconds, from the start of the reaction. **<u>All data</u>** were accurately recorded in the table.

Time(sec)	***Reactants total mass loss (grams)***			
	Beaker B	Beaker A	Beaker C	Beaker **D**
0.00	0.00	0.00	0.00	0.00
2	0.40	0.30	0.60	0.80
4	0.58	0.50	0.70	0.90
6	0.64	0.56	0.90	1.10
8	0.75	0.66	0.93	1.20
10	0.82	0.70	0.93	1.31
12	0.92	0.74	0.93	1.30
14	0.92	0.20	0.92	1.29
16	0.92	0.80	0.93	1.30

a) Plot the graphs of the above data on one set of axes on the graphing grid below.



b) Formulate an appropriate hypothesis for this experiment.

c) Explain the results in terms of the particle -collision theory.

d) What does the gradient of each graph indicate?

e) How would you improve this experiment?

f) Give an explanation as to how beaker B may be different to the others.

g) In which beaker is the reaction still proceeding at a slow rate after 18 seconds? Explain why.