Chemistry in society

Ink exercise

Equilibrium, Hess Law, Enthalpy

Multiple choice – 10 marks

1) $Cl_2(g) + H_2O(l) \rightleftharpoons Cl^-(aq) + ClO^-(aq) + 2H^+(aq)$
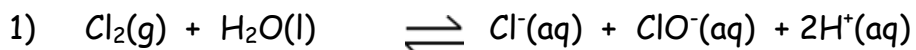
The addition of which substance would move the above equilibrium to the right?

    A   Hydrogen chloride

    B   Sodium chloride

    C   Sodium hydroxide

    D   Hydrogen

2) Under the conditions used industrially, ethene and steam react as follows:

$C_2H_4(g) + \rightleftharpoons H_2O(g) \qquad C_2H_5OH(g) \qquad \Delta H = -46kJ\ mol^{-1}$

Which set of conditions would give the best yield of ethanol at equilibrium?

    A   High temperature, low pressure

    B   High temperature, high pressure

    C   Low temperature, high pressure

    D   Low temperature, low pressure

3) Which entry in the table shows the effect of a catalyst on the reaction rates and position of equilibrium in a reversible reaction?

	Rate of forward reaction	Rate of reverse reaction	Position of equilibrium
A	Increased	Unchanged	Moves right
B	Increased	Increased	Unchanged
C	Increased	Decreased	Moves right
D	unchanged	unchanged	Unchanged

4) Which of the following represents an enthalpy of combustion?

    A CH_3CHO + $\frac{1}{2}O_2$ → CH_3COOH
    B C_2H_5OH + O_2 → CH_3COOH + H_2O
    C C_2H_6 + $3\frac{1}{2}O_2$ → $2CO_2$ + $3H_2O$
    D CH_4 + H_2O → CO + $3H_2$

5) When 10g of a substance with molecular mass of 67.2 is completely burned in oxygen, the heat enthalpy released is 300kJ.
    The enthalpy of combustion of the substance is

    A   -30kJ mol^{-1}
    B   -3700kJ mol^{-1}
    C   -2016kJ mol^{-1}
    D   -3000kJ mol^{-1}

6) Consider the reaction

    C → $\frac{1}{2}A$ + $1\frac{1}{2}B$ ΔH = +48kJ mol^{-1}
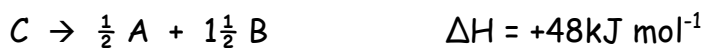
    What is ΔH for the reaction A + $3B$ → $2C$?

    A   -96kJ
    B   -48kJ
    C   +96kJ
    D   +48kJ

7) $N_2(g)$ + $2O_2(g)$ → $2NO_2(g)$ ΔH = +88kJ
    $N_2(g)$ + $2O_2(g)$ → $N_2O_4(g)$ ΔH = +10kJ

    The enthalpy change for the reaction
       $2NO_2(g)$ → $N_2O_4(g)$ will be

    A   +98kJ
    B   +78kJ
    C   -78kJ
    D   -98kJ

8) Consider the reaction pathway shown:

$$X$$

$C(s) + O_2(g) \longrightarrow CO(g) + \tfrac{1}{2} O_2(g)$

-393.5kJ mol^{-1}   **-283kJ mol^{-1}**

$CO_2(g)$
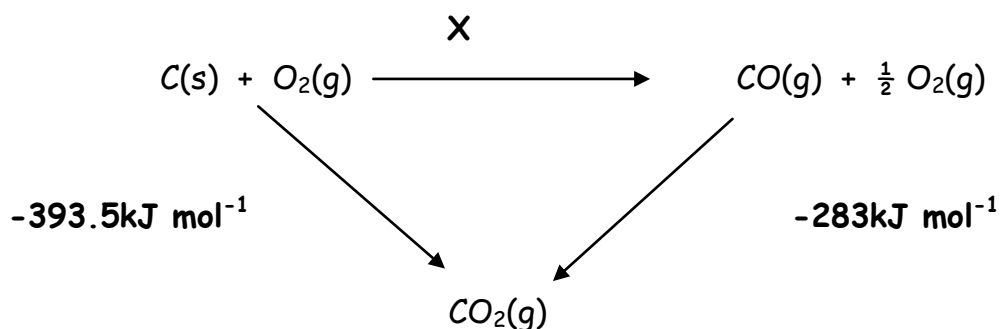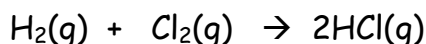
According to Hess' Law, what is the enthalpy change for reaction X?

A   +110.5kJ mol^{-1}
B   -110.5kJ mol^{-1}
C   -676.5kJ mol^{-1}
D   +676.5kJ mol^{-1}

9) Which of the following represents the bond enthalpy for the H-Cl bond?
A $2HCl (g) \rightarrow H_2(g) + Cl_2(g)$
B $HCl (g) \rightarrow H(g) + Cl(g)$
C $HCl (g) \rightarrow \tfrac{1}{2} H_2(g) + \tfrac{1}{2}Cl_2(g)$
D $HCl (l) \rightarrow H(g) + Cl(g)$

10) Hydrogen chloride can be formed from its elements as shown:
$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$
The Cl-Cl bond enthalpy is 242kJ mol^{-1}
The H-H bond enthalpy is 436kJ mol^{-1}
The H-Cl bond enthalpy is 431kJ mol^{-1}

Using these values, the enthalpy change for the formation of 2 moles of HCl is:

A   +184kJ
B   -184kJ
C   +862kJ
D   -862kJ

Written – 20 marks

11) Synthesis gas, a mixture of hydrogen and carbon monoxide, is prepared as shown below. Nickel is known to catalyse the reaction.

$$CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$$
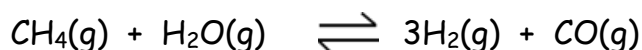
a) An increase in temperature increases the yield of synthesis gas. What information does this give about the enthalpy change in the forward reaction? (1)

b) Using Le Chatelier's principle explain how a change in pressure will affect the composition of the equilibrium mixture. (2)

c) State how the rate of formation of synthesis gas will be affected by the use of a catalyst. (1)

d) State how the concentration of the equilibrium mixture will be affected by the use of a catalyst. (1)

12a) Write equations to describe the enthalpies of combustion of hydrogen and ethane. (1)

b) Given that $\quad C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O \qquad \Delta H = -1411kJ\ mol^{-1}$
use this equation and the enthalpies of combustion from part (a) above to calculate the enthalpy change for the reaction below: (3)

$$C_2H_4 + H_2 \rightarrow C_2H_6$$
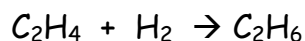
13) A group of students carried out experiments to find the enthalpy of combustion of butan-1-ol (C_4H_9OH).
   Their results are shown on the graph.

Heat released (kJ)

Mass of butan-1-ol burned (g)
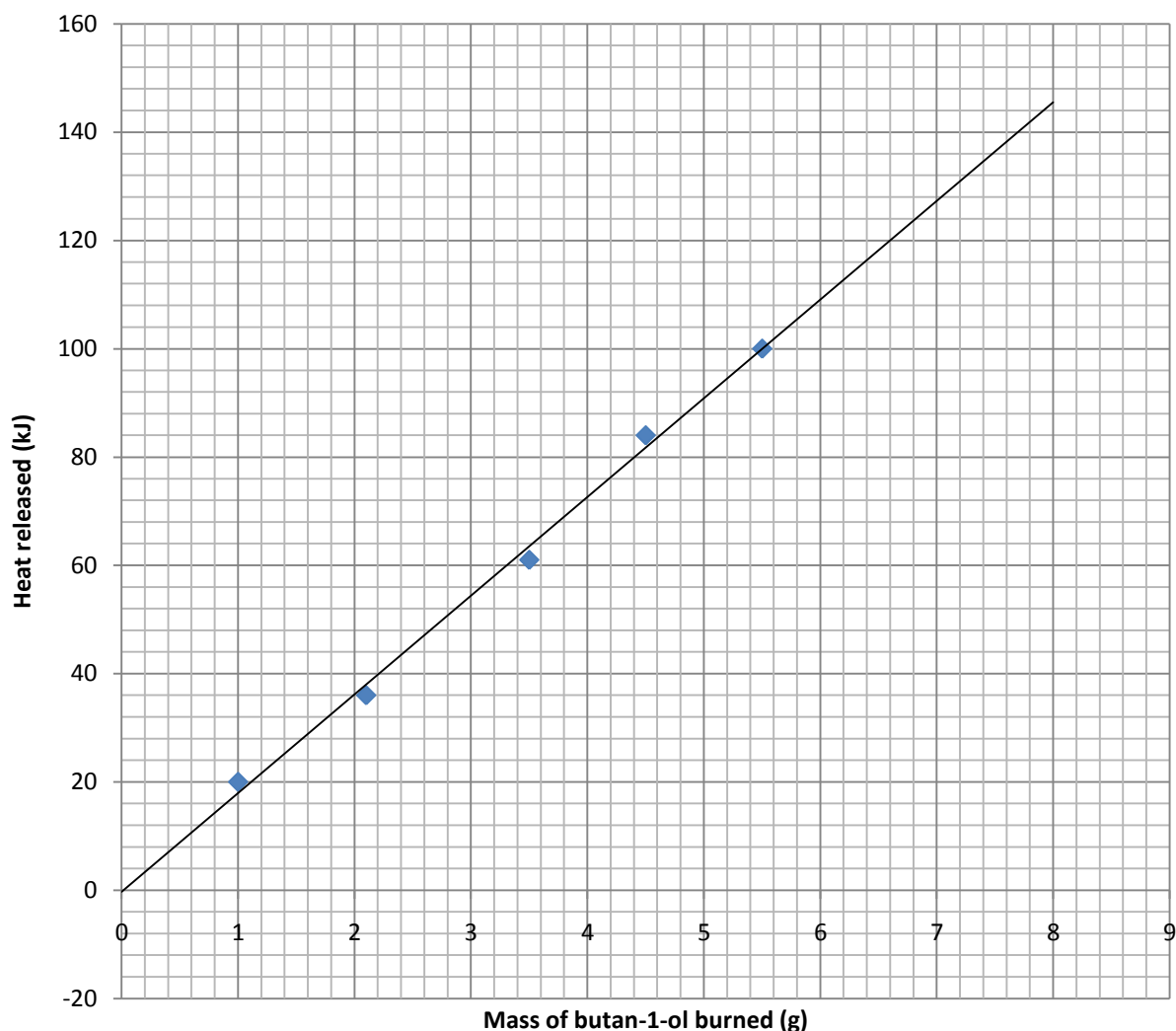
a) Use the graph to find the heat released by burning 0.10 mol of butan-1-ol   (1)

b) Draw a labelled diagram of the assembled apparatus the students could
   have used to carry out the experiments.   (2)

c) The students repeated the experiment with ethanol. They found that
   burning 0.980g of ethanol resulted in the temperature of 400cm^3 of
   water rising from 14.2°C to 31.6°C.
   Use this information to calculate the enthalpy of combustion of ethanol.   (3)
   **Show your working clearly.**

14a) Ammonia can be formed as shown below:

$N_2(g)$ + $3H_2(g)$ $\rightleftharpoons$ $2NH_3(g)$
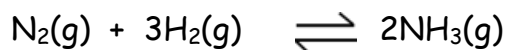
Use the bond enthalpies in the table below to calculate the enthalpy for the formation of 2 moles of ammonia. (2)

Bond	Bond enthalpy (kJ mol^{-1})
N—H	391
N≡N	941
H—H	435

b) The ammonia can be used to make ammonium chloride by two different routes.

ΔH_1 = -109kJ

$NH_3(g)$ + $HCl(aq)$ $\longrightarrow$ $NH_4Cl(aq)$

ΔH_2 = ?   + H_2O + HCl

ΔH_3 = -63kJ

$NH_4OH(aq)$
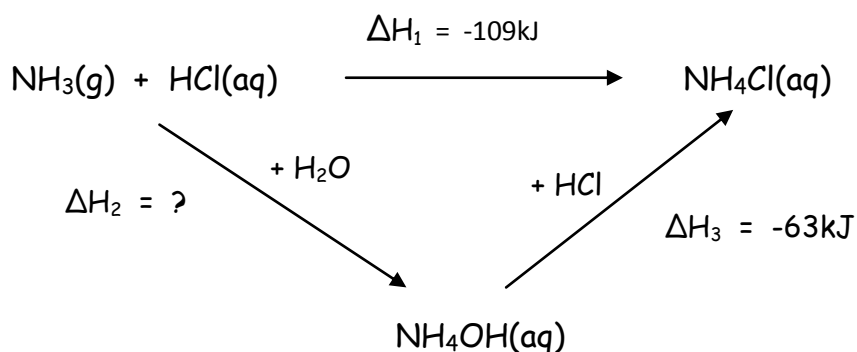
i) Write an equation to show how ΔH_1, ΔH_2 and ΔH_3 are related. (1)
ii) What is the value of ΔH_2 in the reaction sequence shown above? (1)
iii) What effect would a catalyst have on the overall enthalpy change? (1)

Total = 30 marks