Chemical energetics – 2022 June AS Chemistry 9701

1. June/2022/Paper_11/No.9

The equation for an enthalpy change is shown. The enthalpy change is Q.

$$2C(s) + 3H_2(g) + 3.5O_2(g) \xrightarrow{Q} 2CO_2(g) + 3H_2O(l)$$

What is the correct expression to calculate Q?

A $2 \times \Delta H_c^{\ominus}[CO_2(g)] - 3 \times \Delta H_f^{\ominus}[H_2(g)]$

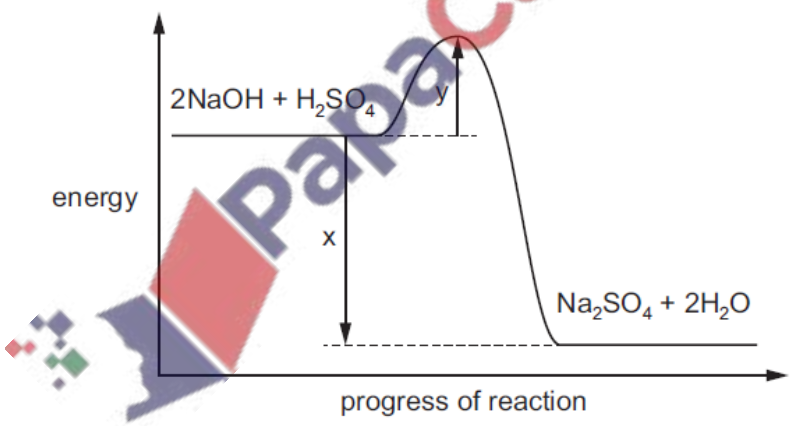
B $3 \times \Delta H_f^{\ominus}[H_2O(g)] + 2 \times \Delta H_c^{\ominus}[CO_2(g)]$

C $2 \times \Delta H_f^{\ominus}[CO_2(g)] - 3 \times \Delta H_f^{\ominus}[H_2(g)]$

D $3 \times \Delta H_f^{\ominus}[H_2O(l)] + 2 \times \Delta H_f^{\ominus}[CO_2(g)]$

2. June/2022/Paper_11/No.10

A reaction pathway diagram for the reaction of aqueous sodium hydroxide and dilute sulfuric acid is shown.



What is the value of the enthalpy change of neutralisation, ΔH_{neut}?

A x **B** x – y **C** $\frac{x}{2}$ **D** $\frac{(x-y)}{2}$

3. June/2022/Paper_12/No.9

The standard enthalpy of formation of $NO_2(g)$ is $+33.2\,kJ\,mol^{-1}$.

The standard enthalpy of formation of $N_2O_4(g)$ is $+9.2\,kJ\,mol^{-1}$.

What is the standard enthalpy change for the reaction $2NO_2(g) \rightarrow N_2O_4(g)$?

A $-57.2\,kJ\,mol^{-1}$

B $-24.0\,kJ\,mol^{-1}$

C $+42.4\,kJ\,mol^{-1}$

D $+75.6\,kJ\,mol^{-1}$

4. June/2022/Paper_12/No.10

Separate samples of $25.0\,cm^3$ of $0.1\,mol\,dm^{-3}$ NaOH(aq) are added to each of three different acid solutions, as described. The temperature of each of the solutions was 298 K before mixing.

sample	acid	type of acid	concentration / mol dm^{-3}	volume / cm^3
1	H_2SO_4	strong	0.05	25.0
2	HC*l*	strong	0.05	25.0
3	CH_3CO_2H	weak	0.05	25.0

Which statement describes the temperature rises that occur on mixing each of these three acids separately with NaOH?

A The temperature rise in all three mixtures is the same.

B The temperature rise using H_2SO_4 and HC*l* is the same.

C The temperature rise using CH_3CO_2H is greater than using HC*l*.

D The greatest temperature rise occurs using H_2SO_4.

5. June/2022/Paper_13/No.9

Which equation represents an enthalpy change that is the average bond energy of the C–H bond in methane?

A $\frac{1}{4}C(g) + H(g) \rightarrow \frac{1}{4}CH_4(g)$

B $\frac{1}{4}CH_4(g) \rightarrow \frac{1}{4}C(g) + H(g)$

C $CH_4(g) \rightarrow C(g) + 4H(g)$

D $CH_4(g) \rightarrow CH_3(g) + H(g)$

6. June/2022/Paper_13/No.10

Magnesium carbonate decomposes when heated in a Bunsen burner flame.

Values for the standard enthalpies of formation, $\Delta H_f^\ominus$, of the species involved are shown.

$\Delta H_f^\ominus$ $MgCO_3$ = –1095.8 kJ mol^{-1}

$\Delta H_f^\ominus$ MgO = –601.7 kJ mol^{-1}

$\Delta H_f^\ominus$ CO_2 = –393.5 kJ mol^{-1}

What is the standard enthalpy change for the decomposition of magnesium carbonate?

A +100.6 kJ mol^{-1}

B +887.6 kJ mol^{-1}

C +1095.8 kJ mol^{-1}

D +2091 kJ mol^{-1}

7. June/2022/Paper_21/No.1(f)

(f) Magnesium, Mg, burns in oxygen, O_2.
The activation energy, E_a, for this reaction is +148 kJ mol^{-1}.

(i) State **one** observation when magnesium burns in oxygen.
Do **not** refer to temperature changes in your answer.

..... [1]

(ii) On Fig. 1.1:

- sketch a reaction pathway diagram for the reaction that occurs when Mg burns in O_2
- label the diagram to show the enthalpy change, ΔH, and the activation energy, E_a, for the reaction.

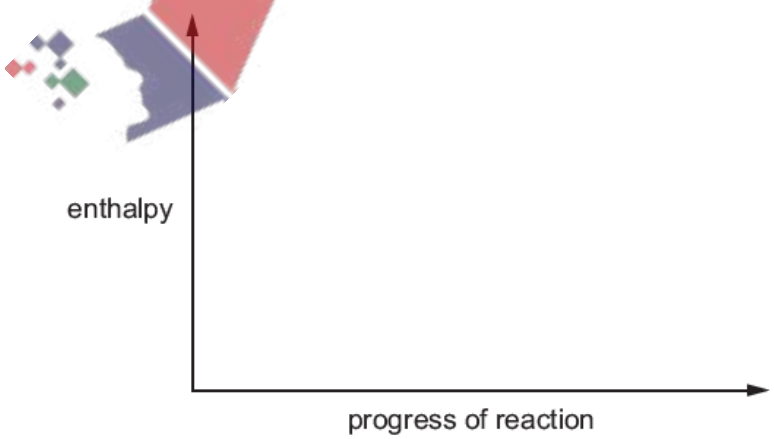


Fig. 1.1

[3]

8. June/2022/Paper_22/No.1(b)

(b) When magnesium is heated in air, magnesium oxide, MgO, is the major product. Smaller amounts of magnesium nitride, Mg_3N_2, are also made.

(i) Calculate the oxidation number for magnesium and for the nitrogen species in Mg_3N_2 to complete Table 1.1.

Table 1.1

species	magnesium in Mg_3N_2	nitrogen in Mg_3N_2
oxidation number		

[1]

(ii) Identify the type of reaction which takes place between magnesium and nitrogen. Explain your answer.

.....

..... [1]

(iii) Define enthalpy change of formation.

.....

..... [2]

(iv) When 3.645 g of Mg(s) burns in excess $N_2(g)$ to form $Mg_3N_2(s)$, 23.05 kJ of energy is released.

Calculate the enthalpy change of formation, ΔH_f, of Mg_3N_2. Show your working.

ΔH_f (Mg_3N_2) = ... [3]

9. June/2022/Paper_23/No.3a(ii)

(ii) Calculate the bond energy of C≡O using the bond energy values in Table 3.1 and the enthalpy change, ΔH, for the thermal decomposition of **G**. Show your working.

Table 3.1

bond	bond energy / kJ mol^{-1}
C–C	350
C–O (in **G**)	360
C–H	410

bond energy (C≡O) = ... kJ mol^{-1}

[2]