Core Worksheet – Chapter 5

1 The equation shows the combustion of hydrogen:

$$H_2(g) + {}^1/_2O_2(g) \rightarrow H_2O(l) \qquad \Delta H = -286 \text{ kJ mol}^{-1}$$

a State the meaning of '$\Delta H = -286$ kJ mol^{-1}'. [3]

b Draw an energy level diagram for this reaction. [3]

2 The specific heat capacities of some metals are shown in the table:

Metal	Specific heat capacity / J g^{-1} K^{-1}
aluminium	0.900
cobalt	0.435
gold	0.130
magnesium	1.03
titanium	0.523

a 100 J of heat energy is supplied to 10.0 g of cobalt. Calculate by how much the temperature (in °C) of the cobalt will rise. [1]

b 1.00 kJ of heat energy is supplied to 5.00 g of each of the metals in the table. For which metal will this result in the greatest temperature rise? [1]

c A piece of titanium of mass 100.0 g and at a temperature of 75.0 °C is placed in a beaker containing 200.0 g of water (specific heat capacity 4.18 J g^{-1} K^{-1}) at a temperature of 16.0 °C. When the titanium is removed after a short time it has cooled to 51.0 °C. Calculate the temperature of the water in the beaker. [4]

d 50.0 g of gold at a temperature of 85.0 °C is put into a beaker containing 100.0 g of water (specific heat capacity 4.18 J g^{-1} K^{-1}) initially at a temperature of 20.0 °C. The two eventually come to a common temperature; calculate that common temperature. (Assume no heat loss to the surroundings.) [4]

3 Use the data given to calculate the enthalpy change (in kJ mol^{-1}) when 1.00 mol of each of the following is burnt. (Specific heat capacity of water is 4.18 J g^{-1} K^{-1}.)

a Ethene; when 0.21 g of ethene is burnt the temperature of 100.0 g of water is raised by 19.0 °C. [4]

b Benzene; when 1.20 g of benzene is burnt the temperature of 1.00 kg of water increases from 19.1 °C to 30.0 °C. [4]

4 50.0 cm^3 of 1.50 mol dm^{-3} sodium hydroxide is mixed with 100.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid. Both solutions were initially at 19.3 °C and when they were mixed the temperature rose to a maximum of 28.3 °C.

a Write an equation for the reaction that occurs. [1]

b Calculate the number of moles of sodium hydroxide and of hydrochloric acid. [2]

c Calculate the enthalpy change of neutralisation. [3]

5 Given these enthalpy changes:

$CH_3CH_2CH_2OH(l) + {}^9/_2O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ $\Delta H^\ominus = -2010$ kJ mol^{-1}

$CH_3CH_2CH_2OH(g) + {}^9/_2O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ $\Delta H^\ominus = -2055$ kJ mol^{-1}

calculate the enthalpy change for the following process: [2]

$CH_3CH_2CH_2OH(g) \rightarrow CH_3CH_2CH_2OH(l)$

6 Given these enthalpy changes:

$Xe(g) + F_2(g) \rightarrow XeF_2(g)$ $\Delta H^\ominus = -100$ kJ mol^{-1}

$Xe(g) + 2F_2(g) \rightarrow XeF_4(g)$ $\Delta H^\ominus = -200$ kJ mol^{-1}

calculate the enthalpy change for the following process: [2]

$XeF_2(g) + F_2(g) \rightarrow XeF_4(g)$

7 Define, using an equation, the bond energy of H–Br. [1]

8 Use the bond energies given in the table to calculate enthalpy changes for reactions below.

Bond	Bond enthalpy / kJ mol^{-1}
C–C	348
C=C	612
C≡C	837
N–N	163
N=N	409
N≡N	944

Bond	Bond enthalpy / kJ mol^{-1}
C–H	412
N–H	388
O–H	463
O–O	146
O=O	496
H–H	436

Bond	Bond enthalpy / kJ mol^{-1}
C–O	360
C=O	743
C≡O	1070
Cl–H	431

a $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(g)$ [5]

b $CO(g) + 3H_2(g) \rightarrow CH_4(g) + H_2O(g)$ [5]

c $4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(g)$ [5]

9 Use the data given below and the bond energies in question 8 to calculate the Cl–Cl bond energy. [5]

$4HCl(g) + O_2(g) \rightarrow 2H_2O(g) + 2Cl_2(g)$ $\Delta H^\ominus = -112$ kJ mol^{-1}

10 Given these enthalpy changes:

$MgCl_2(s) \rightarrow Mg^{2+}(g) + 2Cl^-(g)$ $\Delta H^\ominus = +2490$ kJ mol^{-1}

$Mg^{2+}(g) \rightarrow Mg^{2+}(aq)$ $\Delta H^\ominus = -1920$ kJ mol^{-1}

$Cl^-(g) \rightarrow Cl^-(aq)$ $\Delta H^\ominus = -360$ kJ mol^{-1}

calculate the enthalpy change for the following process: [4]

$MgCl_2(s) \rightarrow MgCl_2(aq)$