I am able to

1   Understand the difference between heat and temperature.

2   Understand the difference between exothermic and endothermic reactions in terms of temperature changes and transfer of heat.

3   State the signs of ΔH for exothermic and endothermic reactions

4   State whether the products are more or less stable than the reactants in an exothermic reaction

5   Draw potential energy profiles/energy level diagrams for exothermic and endothermic reactions.

6   State whether combustion is an exothermic or endothermic process

7   State whether the neutralisation reaction when an acid reacts with an alkali is an exothermic or endothermic process

8   Calculate the enthalpy change of combustion of hexane given that when 1.20 g of hexane (C_6H_{14}) is burnt the temperature of 250.0 g of water (specific heat capacity 4.18 J g^{-1} ^{o}C) is raised by 56.0 ^{o}C.

9   Give two reasons why the enthalpy change in 8 is less exothermic than the literature value.

10   Describe an experimental procedure which could be used to measure the enthalpy change of a reaction occurring in aqueous solution.

11   Calculate the enthalpy change of solution (for 1 mol of substance dissolving) given that, when 0.950 g of magnesium chloride is dissolved in 25.0 cm^3 of water the temperature rises by 14 ^{o}C. Explain 2 assumptions that have been made in the calculation.

12   Explain Hess's Law.

13   Define the standard enthalpy change of formation for a substance

14   Explain what is meant by *standard conditions*

15   Explain what is meant by *standard state*

16   Write equations which represents the standard enthalpy change of formation of

$CH_4(g)$ $CO(g)$ $H_2SO_4(l)$ $Mg(NO_3)_2(s)$ $CH_3COOH(l)$

17   Explain why the standard enthalpy change of formation of $O_2(g)$ is zero.

18   Write an equation which represents the standard enthalpy change of combustion of

$H_2(g)$ $CH_4(g)$ $CH_3OH(l)$

19   Calculate the standard enthalpy change of combustion of methanol using standard enthalpies of formation, ΔH_f^{e}

Compound	$CH_3OH(l)$	$CO_2(g)$	$H_2O(l)$
ΔH_f^{e} / kJ mol^{-1}	-240	-400	-290

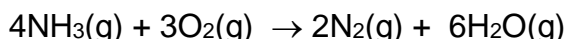20 Calculate the enthalpy changes for the following reactions given enthalpy change of formation data

	ΔH_f^e / kJ mol^{-1}		ΔH_f^e / kJ mol^{-1}
$SO_2(g)$	-297	$POCl_3(l)$	-597
$PCl_5(s)$	-444	$NH_3(g)$	-46
$SOCl_2(l)$	-246	$NH_4Cl(s)$	-314
$Cl_2O(g)$	80	$H_2O(g)$	-242

(a) $SO_2(g) + PCl_5(s) \rightarrow SOCl_2(l) + POCl_3(l)$

(b) $3Cl_2O(g) + 10NH_3(g) \rightarrow 2N_2(g) + 6NH_4Cl(s) + 3H_2O(g)$

21 Calculate the enthalpy change for a reaction given known enthalpy changes

(a)   Given the values in the table, calculate the enthalpy change for:

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	$\Delta H = -92$ kJ mol^{-1}
$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$	$\Delta H = -484$ kJ mol^{-1}

$4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(g)$

(b)   Given the values in the table, calculate the enthalpy change for:

$3Mn(s) + 2O_2(g) \rightarrow Mn_3O_4(s)$	$\Delta H = -1387$ kJ mol^{-1}
$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$	$\Delta H = -1669$ kJ mol^{-1}

$3Mn_3O_4(s) + 8Al(s) \rightarrow 9Mn(s) + 4Al_2O_3(s)$
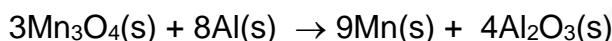
(c)   Given the values in the table, what is the enthalpy change for:

|	
$S(s) + O_2(g) \rightarrow SO_2(g)$	$\Delta H = -297$ kJ mol^{-1}
$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$	$\Delta H = -196$ kJ mol^{-1}
$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(l)$	$\Delta H = -130$ kJ mol^{-1}

$2S(s) + 3O_2(g) + 2H_2O(l) \rightarrow 2H_2SO_4(l)$
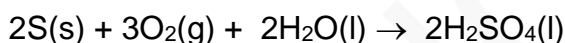
22 Define average bond enthalpy

23 Write an equation to represent the bond enthalpy (energy) of hydrogen fluoride.

24 State whether bond breaking is an exothermic or endothermic process

25 Use the bond energies given below to calculate the enthalpy change for the reaction:

$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$
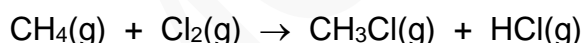
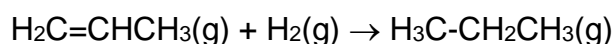| BOND	Bond Energy / kJ mol^{-1}
H-Cl	430
C-Cl	340
C-H	410
Cl-Cl	240

26 Explain in terms of bond enthalpies why the reaction in 25 is exothermic.

27 Explain why bond enthalpies cannot be used to calculate the enthalpy change for the reaction:

$H_2(g) + Br_2(l) \rightarrow 2HBr(g)$
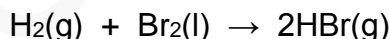
28 Explain why calculations involving bond enthalpies may not be as accurate as those involving enthalpy changes of formation.

29 Use bond enthalpies to work out the enthalpy change for the reaction:

$H_2C=CHCH_3(g) + H_2(g) \rightarrow H_3C-CH_2CH_3(g)$

BOND	Bond Energy / kJ mol^{-1}
C-H	410
C-C	350
H-H	440
C=C	610

30 Using the enthalpy change given and the appropriate bond energies work out the Cl-F bond energy in ClF.

$Cl_{2(g)} + F_{2(g)} \rightarrow 2ClF_{(g)}$ $\Delta H = -106$ kJ mol^{-1}
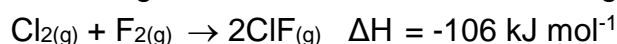
BOND	Bond Energy / kJ mol^{-1}
Cl-Cl	242
F-F	158

31   Explain in terms of bond strengths whether O_2 or O_3 absorbs longer wavelength UV radiation.

32   Write equations representing the following enthalpy changes:

- The first ionisation energy of magnesium

- The atomisation energy of chlorine

- The second electron affinity of oxygen

- The lattice enthalpy of magnesium chloride

- The hydration enthalpy of chloride ions

- The enthalpy change of solution of sodium carbonate

33   Work out enthalpy changes of atomisation from bond enthalpies. The F-F bond enthalpy is 160 kJ mol^{-1}, what is the value of the enthalpy change of atomisation of fluorine?

34   Draw a Born-Haber cycle for the formation of sodium chloride and the data in the table to calculate the standard enthalpy change of formation of sodium chloride.

ΔH_{at} (Na)	100 kJ mol^{-1}
Cl-Cl bond enthalpy	240 kJ mol^{-1}
IE (Na)	500 kJ mol^{-1}
EA (Cl)	-350 kJ mol^{-1}
ΔH_{latt} (NaCl)	800 kJ mol^{-1}

35   Draw Born Haber cycles for the formation of CaO and $MgCl_2$

36   Calculate the enthalpy change of solution of magnesium chloride from hydration enthalpies and the lattice enthalpy

$\Delta H_{hyd}(Mg^{2+})$	-1960 kJ mol^{-1}
$\Delta H_{hyd}(Cl^-)$	-360 kJ mol^{-1}
$\Delta H_{latt}(MgCl_2)$	2540 kJ mol^{-1}

37   Understand the factors that affect the values of lattice enthalpy and enthalpy changes of hydration.

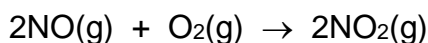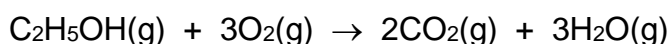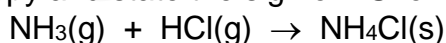(a)   Place the following compounds in order of increasing lattice enthalpy
       KF $MgCl_2$ MgF_2 CaO   CaS   KI

(b)   For each of the following pairs state which has the more exothermic enthalpy of hydration.
       - Na^+ and Mg^{2+}
       - Na^+ and K^+
       - CO_3^{2-} and Cl^-

38   Explain what is meant by *entropy* in terms of the distribution of energy.

39   State and explain whether each of the reactions below involves an increase or decrease in entropy and state the sign of ΔS for each reaction.
 $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

       $C_2H_5OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$

       $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

40   Use the absolute entropies given below to calculate the standard entropy change for

       $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$
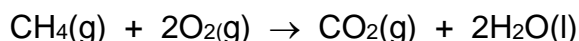
Substance	S^e / J K^{-1} mol^{-1}
$CH_{4(g)}$	185
$O_{2(g)}$	205
$CO_{2(g)}$	215
$H_2O_{(l)}$	70

41   State whether ΔG is positive or negative for a spontaneous reaction.

42   Calculate $\Delta G^{\ominus}$ for the following reaction and state whether it is spontaneous or not at 298 K

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$
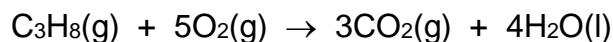
$\Delta H^{\ominus}$ = -2220 kJ mol^{-1} and $\Delta S^{\ominus}$ = -370J K^{-1} mol^{-1}

43   Explain whether a reaction for which ΔS is positive becomes more or less spontaneous as the temperature increases.

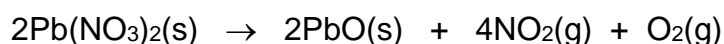44   Explain whether each of the following reactions becomes more or less spontaneous as the temperature increases:
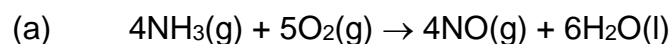
(a) $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$
$\Delta H^{\ominus}$ = -1170 kJ mol^{-1} $\Delta S^{\ominus}$ = -534 J K^{-1} mol^{-1}
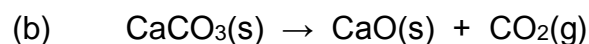
(b) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
$\Delta H^{\ominus}$ = +178 kJ mol^{-1} $\Delta S^{\ominus}$ = +161 J K^{-1} mol^{-1}

45   Work out the temperature (^oC) at which the reaction below becomes spontaneous

$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$

$\Delta H^{\ominus}$ = + 600 kJ mol^{-1} $\Delta S^{\ominus}$ =900 J K^{-1} mol^{-1}