1 When 0.1 mol of aqueous potassium hydroxide was added to 0.1 mol of nitric acid, 5200 J were transferred to the surroundings. What is the enthalpy change, in kJ mol^{-1}, for this reaction?

$$KOH(aq) + HNO_3(aq) \rightarrow KNO_3(aq) + H_2O(l)$$

☒ **A** −52

☒ **B** −26

☒ **C** +26

☒ **D** +52

(Total for Question = 1 mark)

2 Calculate the enthalpy change, in kJ mol^{-1}, for the reaction

$$H_2(g) + ½O_2(g) \rightarrow H_2O(g)$$

DATA:

Bond	Bond enthalpy / kJ mol^{-1}
H—H	+436
O=O	+498
H—O	+464

☒ **A** −243

☒ **B** −6

☒ **C** +6

☒ **D** +221

(Total for Question = 1 mark)

3 The table shows some data about metal ions, non-metal ions and their compounds.

Ion	Enthalpy change of hydration / kJ mol^{-1}	Compound	Lattice energy / kJ mol^{-1}
$Mg^{2+}(g)$	–1921	$MgCl_2(s)$	–2526
$Cl^-(g)$	–340		
$Cs^+(g)$	–276	CsF(s)	–747
$F^-(g)$	–483		

Use the data to calculate

(a) the standard enthalpy change, in kJ mol^{-1}, for the following process.

$$Mg^{2+}(g) + 2Cl^-(g) \rightarrow Mg^{2+}(aq) + 2Cl^-(aq)$$

(1)

☒ **A** –1241

☒ **B** –1581

☒ **C** –2261

☒ **D** –2601

(b) the standard enthalpy change of solution, in kJ mol^{-1}, of caesium fluoride, CsF.

(1)

☒ **A** –12

☒ **B** +12

☒ **C** –1506

☒ **D** +1506

(Total for Question = 2 marks)

4 The standard enthalpy change for the combustion of graphite is –393.5 kJ mol^{-1} and that of diamond is –395.4 kJ mol^{-1}.

What is the standard enthalpy change for the reaction below, in kJ mol^{-1}?

$$C(s, \text{graphite}) \rightarrow C(s, \text{diamond})$$

☒ **A** –1.9

☒ **B** +1.9

☒ **C** –788.9

☒ **D** +788.9

(Total for Question = 1 mark)

5 The standard enthalpy change of neutralization when an acid reacts with an alkali is the number of kilojoules released by the

☒ **A** formation of one mole of salt.

☒ **B** formation of one mole of water.

☒ **C** neutralization of one mole of acid.

☒ **D** neutralization of one mole of alkali.

(Total for Question = 1 mark)

6 Consider the following bond enthalpy values.

Bond	Bond enthalpy / kJ mol^{-1}
O—O	+146
O—H	+463
O═O	+496

For the reaction

$$H—O—O—H(g) \rightarrow H—O—H(g) + \tfrac{1}{2}O═O(g)$$

the enthalpy change, in kJ mol^{-1}, is

☒ **A** –102

☒ **B** +102

☒ **C** +350

☒ **D** +394

(Total for Question = 1 mark)

7 Using the data in the table below, calculate the standard enthalpy change, in kJ mol^{-1}, for the reaction between carbon disulfide, CS_2, and oxygen shown in the following equation.

$$CS_2(g) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$$

Substance	Standard enthalpy change of formation, $\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CS_2(g)$	+110
$CO_2(g)$	–390
$SO_2(g)$	–290

☒ **A** –570

☒ **B** –790

☒ **C** –860

☒ **D** –1080

(Total for Question = 1 mark)

8 The reaction for which the enthalpy change is the standard enthalpy change of formation of water, $\Delta H^{\ominus}_{f,298}$, is

☒ **A** $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$

☒ **B** $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$

☒ **C** $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

☒ **D** $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

(Total for Question = 1 mark)

9 Which equation represents the reaction for which the enthalpy change, ΔH, is the mean bond energy of the C-F bond?

☒ **A** $CF_4(g) \rightarrow C(g) + 4F(g)$

☒ **B** $\frac{1}{4}CF_4(g) \rightarrow \frac{1}{4}C(g) + F(g)$

☒ **C** $C(g) + 4F(g) \rightarrow CF_4(g)$

☒ **D** $\frac{1}{4}C(g) + F(g) \rightarrow \frac{1}{4}CF_4(g)$

(Total for Question = 1 mark)

10 Given the following information

$$CH_4(g) \rightarrow C(g) + 4H(g) \qquad \Delta H = +Q \text{ kJ mol}^{-1}$$

the mean bond enthalpy for the C—H bond in methane is

☒ **A** $+Q$

☒ **B** $+Q/4$

☒ **C** $-Q$

☒ **D** $-Q/4$

(Total for Question = 1 mark)

11 Consider the following information:

Bond	Bond enthalpy / kJ mol^{-1}
H—H	+436
I—I	+151
H—I	+299

For the reaction

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

the enthalpy change, in kJ mol^{-1}, is

☒ **A** +288

☒ **B** +144

☒ **C** –11

☒ **D** –5.5

(Total for Question = 1 mark)

12 The equation for the complete combustion of butanone, $C_2H_5COCH_3$, is

$$C_2H_5COCH_3(l) + 5\frac{1}{2}O_2(g) \rightarrow 4CO_2(g) + 4H_2O(l) \qquad \Delta H^{\ominus} = -2440 \text{ kJ mol}^{-1}$$

Substance	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CO_2(g)$	–394
$H_2O(l)$	–286

From the above data, the standard enthalpy change of formation of butanone, in kJ mol^{-1}, is

☒ **A** –280

☒ **B** +280

☒ **C** –1760

☒ **D** +1760

(Total for Question = 1 mark)

13 In an experiment to determine the enthalpy change of combustion of an alcohol, a spirit burner containing the alcohol was weighed, lit and placed under a copper can containing a known volume of water. The temperature rise of the water was measured and the burner re-weighed. The enthalpy change calculated from the results was much less exothermic than the value reported in the literature.

Which of the following factors is **most** likely to be the cause of this error?

☒ **A** Heat loss around the side of the copper can.

☒ **B** The use of a thermometer with a range of 0 110 °C rather than 0 50 °C.

☒ **C** The use of a measuring cylinder for measuring the water rather than a pipette.

☒ **D** Evaporation of the alcohol during the weighing.

(Total for Question 1 mark)

14 The standard enthalpy changes of formation of carbon dioxide and of methanoic acid are 394 kJ mol ^{1} and 409 kJ mol ^{1} respectively. Calculate the enthalpy change for the reaction

$$H_2(g) + CO_2(g) \rightarrow HCOOH(l)$$

☒ **A** -803 kJ mol ^{1}

☒ **B** -15 kJ mol ^{1}

☒ **C** +803 kJ mol ^{1}

☒ **D** +15 kJ mol ^{1}

(Total for Question 1 mark)

15 For which of the following changes is the value of ΔH negative?

☒ **A** $K(g) \rightarrow K^{+}(g) + e$

☒ **B** $K^{+}Cl\ (s) \rightarrow K^{+}(g) + Cl\ (g)$

☒ **C** $Cl(g) + e \rightarrow Cl\ (g)$

☒ **D** $Cl_2(g) \rightarrow 2Cl(g)$

(Total for Question 1 mark)

16 The enthalpy change for the reaction between hydrochloric acid and sodium hydroxide is 56 kJ mol ^{1}. Therefore

☒ **A** the reaction is exothermic and the temperature rises.

☒ **B** the reaction is exothermic and the temperature falls.

☒ **C** the reaction is endothermic and the temperature rises.

☒ **D** the reaction is endothermic and the temperature falls.

(Total for Question 1 mark)

17 For which of the following reactions is the enthalpy change equal to the bond enthalpy of H I?

☒ **A** $HI(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}I_2(s)$

☒ **B** $HI(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}I_2(g)$

☒ **C** $HI(g) \rightarrow H(g) + I(g)$

☒ **D** $HI(g) \rightarrow H^{+}(g) + I(g)$

(Total for Question 1 mark)

18 The equation for the complete combustion of pentane is

$$C_5H_{12}(g) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l) \qquad \Delta H_c^{\ominus} \qquad 3509 \text{ kJ mol}^{1}$$

The standard enthalpy change of formation of $CO_2(g)$ is 394 kJ mol ^{1} and that of $H_2O(l)$ is 286 kJ mol ^{1}.

The standard enthalpy change of formation of pentane (in kJ mol ^{1}) is

☒ **A** 5(394) + 6(286) + (3509)

☒ **B** 5(394) + 6(286) (3509)

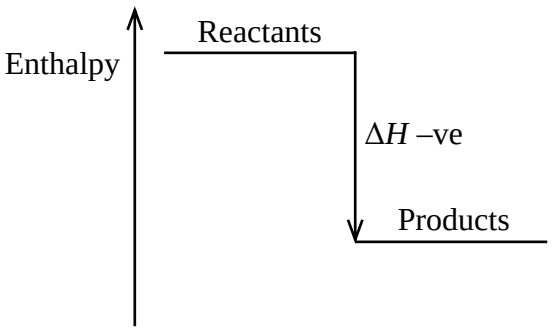
☒ **C** 5(394) 6(286) + (3509)

☒ **D** 5(394) 6(286) (3509)

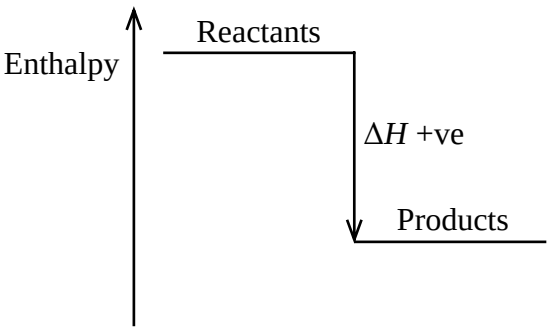
(Total for Question 1 mark)

19 Which of these diagrams correctly represents an endothermic reaction?

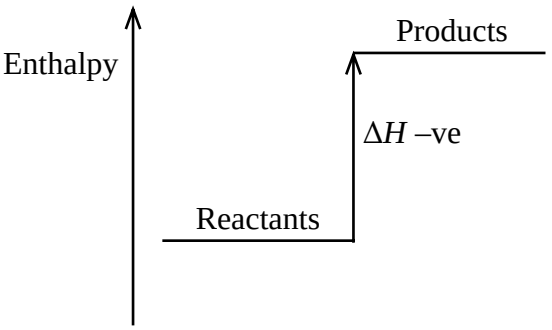
☒ **A**



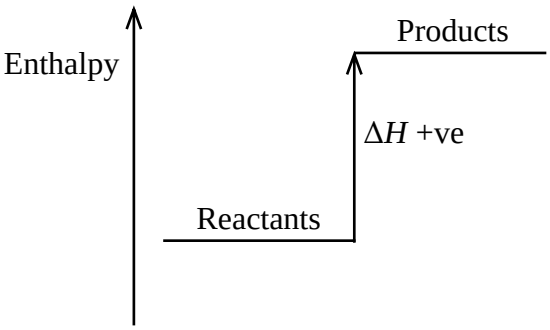
☒ **B**



☒ **C**



☒ **D**



(Total for Question = 1 mark)

20 Some mean bond enthalpy values are given in the table below.

Bond	Mean bond enthalpy / kJ mol^{-1}
H—H	+436
I—I	+151
H—I	+299

What is the enthalpy change for the reaction shown below in kJ mol^{-1}?

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

☒ **A** 436 + 151 – 299 = +288

☒ **B** –436 – 151 + 299 = –288

☒ **C** +436 +151 – (2 × 299) –11

☒ **D** –436 – 151 + (2 × 299) = +11

(Total for Question = 1 mark)

21 In an experiment to measure the enthalpy change of a reaction involving gases, which of the following conditions must always be kept constant?

☒ **A** Pressure

☒ **B** Temperature

☒ **C** Volume

☒ **D** Temperature and pressure

(Total for Question = 1 mark)

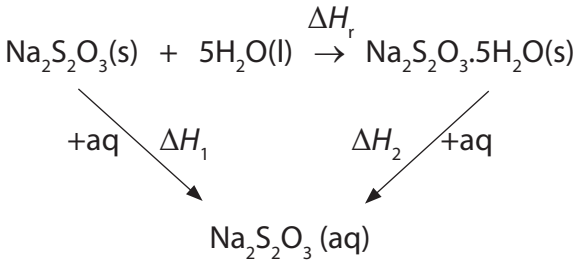
22 In an endothermic reaction in aqueous solution, which of the following is correct?

	Temperature	Sign of enthalpy change
☒ **A**	Increases	Positive
☒ **B**	Increases	Negative
☒ **C**	Decreases	Positive
☒ **D**	Decreases	Negative

(Total for Question = 1 mark)

23 The enthalpy change for the reaction to form hydrated sodium thiosulfate crystals cannot be measured directly.

The following Hess cycle can be used.



The enthalpy change for the reaction, ΔH_r, is equal to

☒ **A** $\Delta H_1 + \Delta H_2$

☒ **B** $\Delta H_1 - \Delta H_2$

☒ **C** $-\Delta H_1 - \Delta H_2$

☒ **D** $-\Delta H_1 + \Delta H_2$

(Total for Question = 1 mark)

24 When 10 cm^3 of 2 mol dm^{-3} hydrochloric acid is reacted with 10 cm^3 of 2 mol dm^{-3} sodium hydroxide solution, the temperature change is ΔT.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

When the reaction is repeated with 50 cm^3 of each solution, the temperature change is

☒ **A** ΔT

☒ **B** $5 \times \Delta T$

☒ **C** $\frac{1}{5} \times \Delta T$

☒ **D** $10 \times 2 \times \Delta T$

(Total for Question = 1 mark)

25 Energy is evolved when one mole of gaseous calcium ions is hydrated.

$$Ca^{2+}(g) + aq \rightarrow Ca^{2+}(aq)$$

This reaction is more exothermic than the corresponding value for barium ions, Ba^{2+}, because the

☒ **A** ionization energy of calcium is greater than that of barium.

☒ **B** lattice energy of calcium oxide is more exothermic than that of barium oxide.

☒ **C** solubility of calcium hydroxide in water is less than that of barium hydroxide.

☒ **D** ionic radius of Ca^{2+} is less than that of Ba^{2+}.

(Total for Question = 1 mark)

26 In an experiment performed to measure the enthalpy change for the reaction

$$Cu^{2+}(aq) + Zn(s) \rightarrow Cu(s) + Zn^{2+}(aq)$$

3.0 g of zinc powder (an excess) was added to 30.0 cm^3 of copper(II) sulfate solution of concentration 1.00 mol dm^{-3}. The temperature rise of the mixture was 47.6 K. Assuming that the heat capacity of the solution is 4.2 J K^{-1} g^{-1}, the enthalpy change for the reaction is given by

☒ **A** ΔH $(30 \times 4.2 \times 47.6) \div 0.03$

☒ **B** ΔH $(33 \times 4.2 \times 47.6) \div 0.03$

☒ **C** ΔH $(30 \times 4.2 \times 47.6) \times 0.03$

☒ **D** ΔH $(33 \times 4.2 \times 47.6) \times 0.03$

(Total for Question 1 mark)

27 The enthalpy change for the reaction

$$C(s, \text{graphite}) + \tfrac{1}{2}O_2(g) \rightarrow CO(g)$$

cannot be measured directly since some carbon dioxide is always formed in the reaction. It can be calculated using Hess's Law and the enthalpy changes of combustion of graphite and of carbon monoxide.

$$C(s, \text{graphite}) + O_2(g) \rightarrow CO_2(g) \quad \Delta H \quad 394 \text{ kJ mol}^{-1}$$

$$CO(g) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g) \quad \Delta H \quad 283 \text{ kJ mol}^{-1}$$

The enthalpy change for the reaction of graphite with oxygen to give carbon monoxide is

☒ **A** 677 kJ mol^{-1}

☒ **B** +111 kJ mol^{-1}

☒ **C** 111 kJ mol^{-1}

☒ **D** +677 kJ mol^{-1}

(Total for Question 1 mark)

28 The molar enthalpy change of combustion of some alkanes is given below in kJ mol ^{1}.

C_3H_8	2219
C_4H_{10}	2877
C_5H_{12}	3509
C_6H_{14}	4163

Another alkane was found to have an enthalpy change of combustion of 6125 kJ mol ^{1}. The alkane is

☒ **A** C_7H_{16}

☒ **B** C_8H_{18}

☒ **C** C_9H_{20}

☒ **D** $C_{10}H_{22}$

(Total for Question 1 mark)

29 If the mean C H bond enthalpy is **+*x***, which of the following represents a process with an enthalpy change of **+4*x***?

☒ **A** $C(g) + 4H(g) \rightarrow CH_4(g)$

☒ **B** $CH_4(g) \rightarrow C(g) + 4H(g)$

☒ **C** $CH_4(g) \rightarrow C(s, \text{graphite}) + 2H_2(g)$

☒ **D** $C(s, \text{graphite}) + 2H_2(g) \rightarrow CH_4(g)$

(Total for Question 1 mark)

30 The enthalpy change for the reaction

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

is +1648 kJ mol ^{1}. Hence the mean bond enthalpy for the C H bond is

☒ **A** +329.6 kJ mol ^{1}

☒ **B** +412.0 kJ mol ^{1}

☒ **C** +1648 kJ mol ^{1}

☒ **D** +6592 kJ mol ^{1}

(Total for Question 1 mark)

31 Which equation represents the reaction for which the enthalpy change is the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, of sodium nitrate, $NaNO_3$?

☒ **A** $2Na(s) + N_2(g) + 3O_2(g) \rightarrow 2NaNO_3(s)$

☒ **B** $Na(s) + ½N_2(g) + 1½O_2(g) \rightarrow NaNO_3(s)$

☒ **C** $Na(s) + N(g) + 3O(g) \rightarrow NaNO_3(s)$

☒ **D** $Na(g) + ½N_2(g) + 1½O_2(g) \rightarrow NaNO_3(g)$

(Total for Question = 1 mark)

32 Which equation represents the reaction for which the enthalpy change, ΔH, is the mean bond enthalpy of the C–H bond?

☒ **A** $¼CH_4(g) \rightarrow ¼C(g) + H(g)$

☒ **B** $CH_4(g) \rightarrow C(s) + 2H_2(g)$

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

☒ **D** $CH_4(g) \rightarrow C(g) + 2H_2(g)$

(Total for Question = 1 mark)