1)

The concentration of blood glucose is usually given in millimoles per dm^3 or mmol dm^{-3}. A reading of 5.0 mmol dm^{-3} is within the normal range. Glucose has a molar mass of 180 g mol^{-1}. What mass of glucose dissolved in 1 dm^3 of blood would give this normal reading?

☒ A   0.090 g

☒ B   0.18 g   ⁼1 mark)

☒ C   0.90 g

☒ D   9.0 g

2)

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

$$Cu^{2+}(aq) + Zn(s) \rightarrow Cu(s) + Zn^{2+}(aq)$$
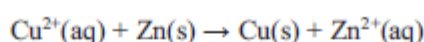
3.0 g of zinc powder (an excess) was added to 30.0 cm^3 of copper(II) sulfate solution of concentration 1.00 mol dm^{-3}. The temperature rise of the mixture was 47.6 K. Assuming that the heat capacity of the solution is 4.2 J $K^{-1} g^{-1}$, the enthalpy change for the reaction is given by

☐ A $\Delta H = -(30 \times 4.2 \times 47.6) \div 0.03$

☐ B $\Delta H = -(33 \times 4.2 \times 47.6) \div 0.03$

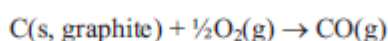☐ C $\Delta H = -(30 \times 4.2 \times 47.6) \times 0.03$ 1 mark)

☐ D $\Delta H = -(33 \times 4.2 \times 47.6) \times 0.03$

3)

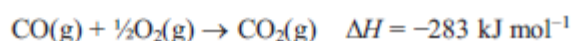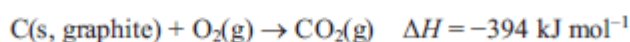The enthalpy change of atomization of iodine is the value of ΔH for the process

☒ A $I_2(s) \rightarrow I_2(g)$

☒ B $I_2(s) \rightarrow 2I(g)$

☐ C $I_2(g) \rightarrow 2I(g)$ 1 mark)

☒ D $\frac{1}{2}I_2(s) \rightarrow I(g)$

4)

The enthalpy change for the reaction

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

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.

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

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

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

☑ A -677 kJ mol^{-1}

☑ B $+111 \text{ kJ mol}^{-1}$

☑ C -111 kJ mol^{-1}

☑ D $+677 \text{ kJ mol}^{-1}$ 1 mark)

5)

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

$$C_3H_8 \quad -2219$$
$$C_4H_{10} \quad -2877$$
$$C_5H_{12} \quad -3509$$
$$C_6H_{14} \quad -4163$$

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

☐ A C_7H_{16}

☐ B C_8H_{18}

☐ C C_9H_{20} ∶ 1 mark)

☐ D $C_{10}H_{22}$

6)

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

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

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

☐ C $CH_4(g) \rightarrow C(s, \text{graphite}) + 2H_2(g)$ ∶ 1 mark)

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

7)

Oxygen can be prepared using several different reactions. Which of those given below has the highest atom economy by mass?

☐ A $NaNO_3 \rightarrow NaNO_2 + \frac{1}{2}O_2$

☐ B $H_2O_2 \rightarrow H_2O + \frac{1}{2}O_2$

☐ C $Cl_2 + H_2O \rightarrow 2HCl + \frac{1}{2}O_2$ ∶ 1 mark)

☐ D $PbO_2 \rightarrow PbO + \frac{1}{2}O_2$

8)

The ionic radii in nm of some ions are given below.

Li^+	0.074	F^-	0.133
Ca^{2+}	0.100	Cl^-	0.180
		O^{2-}	0.140
		S^{2-}	0.185

(a) Which of the following compounds has the most exothermic lattice energy? They all have the same crystal structure.

(1)

☐ A LiF

☐ B LiCl

☐ C CaO

☐ D CaS

(b) Which of the following compounds will show the greatest difference between the experimental (Born-Haber) lattice energy and that calculated from a purely ionic model?

(1)

☐ A LiF

☐ B Li_2O

☐ C CaO   2 marks)

☐ D CaS

9)

Which of the following is the correct order for the processes used to obtain petrol from petroleum (crude oil)?

☐ A   Petroleum → fractional distillation → reforming → cracking → petrol.

☐ B   Petroleum → reforming → fractional distillation → cracking → petrol.

☐ C   Petroleum → cracking → reforming → fractional distillation → petrol.

☐ D   Petroleum → fractional distillation → cracking → reforming → petrol.   1 mark)

10)

In the reaction between ethene and bromine, the bromine molecule acts as an electrophile.

$$CH_2=CH_2 + Br_2 \rightarrow BrCH_2CH_2Br$$
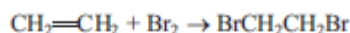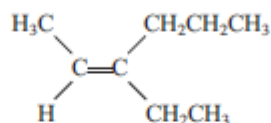
Which of the following statements is true?

☐ A   Ethene acts as a nucleophile because it is polar.

☐ B   Ethene acts as a nucleophile because it can donate a pair of electrons to bromine.

☐ C   Ethene is not a nucleophile in this reaction.   1 mark)

☐ D   Ethene acts as a nucleophile because it donates a single electron to bromine.

#

11)

Name the alkene shown below.

H_3C $CH_2CH_2CH_3$

C=C

H CH_2CH_3

☐ A   Z-4-ethylhex-4-ene

☐ B   E-3-ethylhex-2-ene

☐ C   Z-3-ethylhex-2-ene

1 mark)

☐ D   E-3-propylpent-2-ene

12)

▶ (a) An impure sample of sodium hydrogencarbonate, $NaHCO_3$, of mass 0.227 g, was reacted with an excess of hydrochloric acid. The volume of carbon dioxide evolved was measured at room temperature and pressure and found to be 58.4 cm^3.

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$$
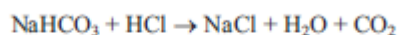
The molar volume of any gas at the temperature and pressure of the experiment is 24 dm^3 mol^{-1}. The molar mass of sodium hydrogencarbonate is 84 g mol^{-1}.

(i)   Calculate the number of moles of carbon dioxide given off.

(1)

(ii) Calculate the mass of sodium hydrogencarbonate present in the impure sample.

(2)

(iii) Calculate the percentage purity of the sodium hydrogencarbonate. Give your answer to two significant figures.

(2)

(b) (i)   The total error in reading the gas syringe is ±0.4 cm^3. Calculate the percentage error in measuring the gas volume of 58.4 cm^3.

(1)

(ii) Suggest why the carbon dioxide should not be collected over water in this experiment.

(1)

13)

(a) On strong heating, calcium carbonate decomposes to calcium oxide and carbon dioxide:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$
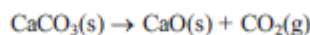
Owing to the conditions under which the reaction occurs, it is not possible to measure the enthalpy change directly.

An indirect method employs the enthalpy changes when calcium carbonate and calcium oxide are neutralized with hydrochloric acid.

(i)   Write the equation for the reaction of calcium carbonate with hydrochloric acid. State symbols are **not** required.

[ΔH_1 is the enthalpy change for this reaction]

(1)

--- ΔH_1

(ii) The reaction of calcium oxide with hydrochloric acid is

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) \qquad \Delta H_2$$
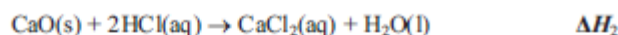
Use the equations in parts (i) and (ii) to complete the Hess's Law cycle below to show how you could calculate the enthalpy change for the decomposition of calcium carbonate, $\Delta H_{reaction}$. Label the arrows in your cycle.

(3)

$$CaCO_3(s) \xrightarrow{\Delta H_{reaction}} CaO(s) + CO_2(g)$$

(iii) Complete the expression for $\Delta H_{reaction}$ in terms of ΔH_1 and ΔH_2.

(1)

$\Delta H_{reaction} =$

(b) Suggest **two** reasons why the value obtained by carrying out these two experiments and using the equation gives a value different to the data booklet value for the decomposition reaction of calcium carbonate.

(2)

14)

Chloroethane can be made from ethane and chlorine in the gas phase in the presence of ultraviolet light. The equation for the reaction is

$$CH_3CH_3 + Cl_2 \rightarrow CH_3CH_2Cl + HCl$$
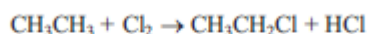
(a) Complete the mechanism for the reaction. Two of the steps have been given for you.

(4)

Initiation: $\qquad\qquad\qquad Cl_2 \rightarrow 2Cl\cdot$

Propagation (two steps)

(i)

(ii)

Termination (three steps)

$$2Cl\cdot \rightarrow Cl_2$$
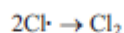
(iii)

(iv)

(b) This reaction gives a poor yield of chloroethane. Give the structural formula and name of another organic product, not included in your mechanism for part (a), which could be produced in the reaction.

(2)

(c) Chlorine gas is extremely toxic and is therefore a significant hazard. The preparation must be performed so as to minimise the risk to the experimenter.

(i) Explain the difference between **hazard** and **risk**.

(2)

(ii) Give one precaution that you would use in this experiment to minimise the risk, other than the use of a laboratory coat and safety goggles.

(1)

15)

(a) The alkenes have the general formula C_nH_{2n}. However, a compound with this general formula is not necessarily an alkene. Suggest why this is so.

(1)

(b) Give the equation, using skeletal formulae, for the reaction of propene with each of the following.

(i) Hydrogen:

(1)

(ii) Hydrogen bromide to form the major product:

(2)

(c) Give the mechanism for the reaction of propene with hydrogen bromide, HBr, to form the major product.

(3)

16)

‣ This question is about the gas ethane, C_2H_6, and its reactions.

(a) Write the equation, including state symbols, which represents the reaction taking place when the standard enthalpy change of combustion of ethane is measured.

(2)

(b) Ethane can react with chlorine to form chloroethane and hydrogen chloride.

$$C_2H_6(g) + Cl_2(g) \rightarrow C_2H_5Cl(g) + HCl(g)$$

Bond	Bond enthalpy/kJ mol^{-1}
C—H	413
C—C	347
C—Cl	346
H—Cl	432
Cl—Cl	243

Rewrite this equation using displayed formulae.

Use the equation you have written, together with the bond enthalpy data, to calculate the enthalpy change for the reaction.

(4)

(c) This reaction takes place in a number of steps, some of which are shown below.

Step 1 $\quad\quad\quad\quad\quad Cl_2 \rightarrow 2Cl\cdot$

Step 2 $\quad CH_3CH_3 + Cl\cdot \rightarrow HCl + CH_3CH_2\cdot$
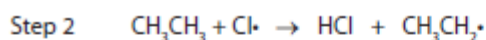
(i) State the type of reaction occurring in step 1 and the conditions needed for this step.

(2)

Type ....

Conditions ....
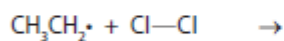
(ii) Complete the equation below for the third step of the reaction, and show the movement of electrons using the appropriate arrows.

(3)

$$CH_3CH_2\cdot + Cl\!-\!Cl \quad\quad \rightarrow$$

(iii) Write equations for **two** termination steps in this reaction.

(2)

(d) Ethane can be cracked in industry. Write an equation for the cracking of ethane.

(1)

(e) Suggest **two** reasons why cracking of larger alkane molecules is important in industry.

(2)