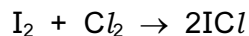
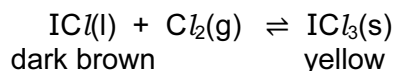


1 Iodine reacts with chlorine to form dark brown iodine monochloride.



This reacts with more chlorine to give yellow iodine trichloride.
An equilibrium forms between these iodine chlorides.



(a) What do you understand by the term *equilibrium*?

.....
.....
..... [2]

(b) When the equilibrium mixture is heated, it becomes a darker brown colour.
Suggest if the reverse reaction is endothermic or exothermic. Give a reason for your choice.

.....
.....
..... [1]

(c) The pressure on the equilibrium mixture is decreased.

(i) How would this affect the position of equilibrium? Give a reason for your choice.

It would move to the

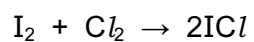
reason

..... [1]

(ii) Describe what you would observe.

.....
..... [1]

- (d) Calculate the overall energy change for the reaction between iodine and chlorine using the bond energy values shown.



Bond	Energy / kJ per mol
I-I	151
Cl-Cl	242
I-Cl	208

Show your working.

[3]

- (e) Draw a labelled energy level diagram for the reaction between iodine and chlorine using the information in (d).

[2]

[Total: 10]

2 Chemical reactions are always accompanied by an energy change.

(a) Aluminium is extracted by the electrolysis of a molten mixture which contains aluminium oxide, Al_2O_3 . This decomposes to form aluminium at the negative electrode and oxygen at the positive electrode.

(i) Write an ionic equation for the reaction at the negative electrode.

..... [2]

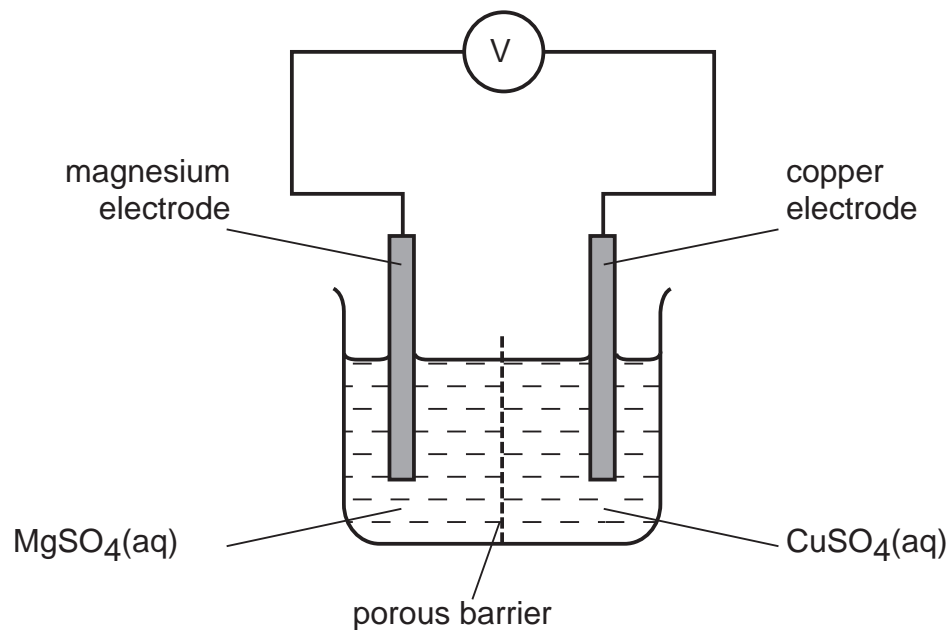
(ii) Complete the ionic equation for the reaction at the positive electrode.



(iii) Is the reaction exothermic or endothermic? Explain your answer.

.....
..... [1]

(b) The cell shown below can be used to determine the order of reactivity of metals.



(i) Is the reaction in the cell exothermic or endothermic? Explain your answer.

.....

..... [1]

(ii) Explain why the mass of the magnesium electrode decreases and the mass of the copper electrode increases.

.....
..... [2]

(iii) How could you use this cell to determine which is the more reactive metal, magnesium or manganese?

.....
..... [2]

(c) The combustion of propane, C_3H_8 , is exothermic.

Give an equation for the complete combustion of propane.

..... [2]

(d) Photosynthesis is an unusual endothermic reaction.

(i) Where does the energy for photosynthesis come from?

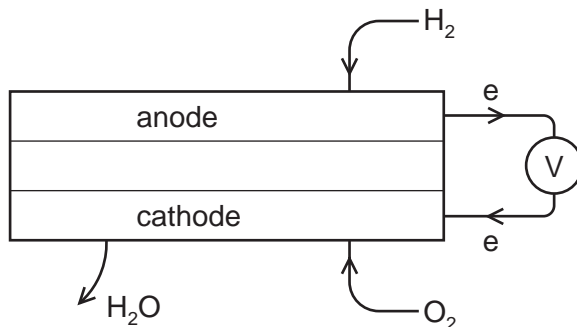
..... [1]

(ii) Give the word equation for photosynthesis.

..... [1]

[Total: 14]

- 3 A fuel cell produces electrical energy by the oxidation of a fuel by oxygen. The fuel is usually hydrogen but methane and methanol are two other fuels which may be used. A diagram of a hydrogen fuel cell is given below.



- (a) When the fuel is hydrogen, the only product is water. What additional product would be formed if methane was used?

..... [1]

- (b) Write the equation for the chemical reaction that takes place in a hydrogen fuel cell.

..... [1]

- (c) At which electrode does oxidation occur? Explain your choice.

..... [1]

- (ii) Write an ionic equation for the reaction at this electrode.

..... [2]

- (d) Fuel cells are used to propel cars. Give **two** advantages of a fuel cell over a gasoline-fuelled engine.

.....
 [2]

[Total: 7]

4 One way of establishing a reactivity series is by displacement reactions.

(a) A series of experiments was carried out using the metals lead, magnesium, zinc and silver. Each metal was added in turn to aqueous solutions of the metal nitrates.

The order of reactivity was found to be:

magnesium most reactive
zinc
lead ↓
silver least reactive

(i) Complete the table.

✓ = reacts

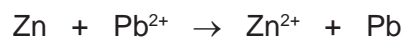
X = does not react

aqueous solution	metal			
	lead Pb	magnesium Mg	zinc Zn	silver Ag
lead(II) nitrate		✓	✓	
magnesium nitrate				
zinc nitrate				
silver nitrate				

[3]

(ii) Displacement reactions are redox reactions.

On the following equation, draw a **ring** around the reducing agent and an **arrow** to show the change which is oxidation.



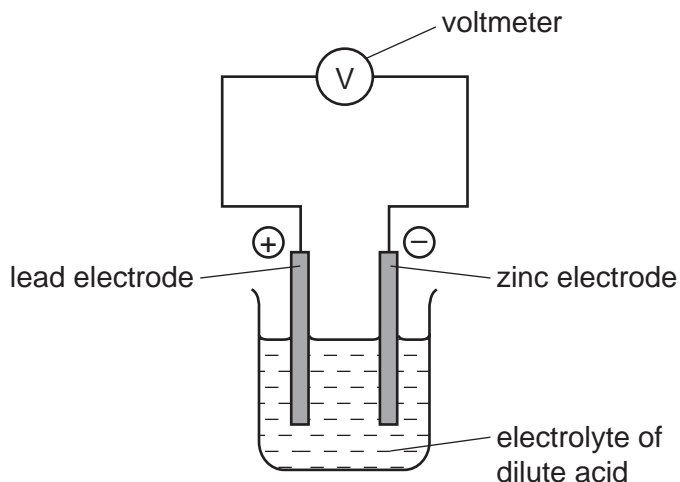
[2]

(iii) Complete the following ionic equation.



[1]

(b) Another way of determining the order of reactivity of metals is by measuring the voltage and polarity of simple cells. The polarity of a cell is shown by which metal is the positive electrode and which metal is the negative electrode. An example of a simple cell is shown below.



(i) Mark on the above diagram the direction of the electron flow. [1]

(ii) Explain, in terms of electron transfer, why the more reactive metal is always the negative electrode.

.....

 [2]

(iii) The following table gives the polarity of cells using the metals zinc, lead, copper and manganese.

cell	electrode 1	polarity	electrode 2	polarity
A	zinc	-	lead	+
B	manganese	-	lead	+
C	copper	+	lead	-

What information about the order of reactivity of these four metals can be deduced from the table?

.....

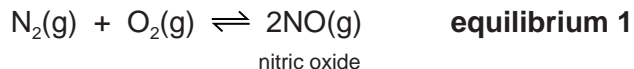
 [2]

(iv) What additional information is needed to establish the order of reactivity of these four metals using cells?

..... [1]

- 5 (a) Nitric acid is now made by the oxidation of ammonia. It used to be made from air and water. This process used very large amounts of electricity.

Air was blown through an electric arc and heated to 3000 °C.



The equilibrium mixture leaving the arc contained 5% of nitric oxide. This mixture was cooled rapidly. At lower temperatures, nitric oxide will react with oxygen to form nitrogen dioxide.



Nitrogen dioxide reacts with oxygen and water to form nitric acid.

- (i) Suggest a reason why the yield of nitric oxide in **equilibrium 1** increases with temperature.

..... [1]

- (ii) What effect, if any, would increasing the pressure have on the percentage of nitric oxide in **equilibrium 1**? Explain your answer.

.....
..... [2]

- (iii) Deduce why **equilibrium 2** is only carried out at lower temperatures.

.....
..... [2]

- (iv) Complete the equation for the reaction between nitrogen dioxide, water and oxygen to form nitric acid.



- (v) Ammonia is more expensive than water and air. Suggest a reason why the ammonia-based process is preferred to the electric arc process.

..... [1]

(b) Nitric acid is used to make the fertiliser ammonium nitrate, NH_4NO_3 .
What advantage has this fertiliser over another common fertiliser, ammonium sulfate,
 $(\text{NH}_4)_2\text{SO}_4$?

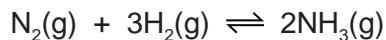
..... [1]

(ii) Plants need nitrogen to make chlorophyll. Explain why chlorophyll is essential for
plant growth.

.....
.....
.....
.....
.....
..... [4]

[Total: 13]

6 Ammonia is made by the Haber process.



(a) State **one** major use of ammonia.

..... [1]

(b) Describe how hydrogen is obtained for the Haber process.

.....
.....
..... [3]

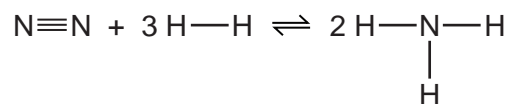
(c) This reaction is carried out at a high pressure, 200 atmospheres.
State, with an explanation for each, **two** advantages of using a high pressure.

.....
.....
.....
.....
..... [5]

(d) What is the difference between an endothermic and an exothermic reaction?

.....
..... [1]

- (ii) Bond breaking is an endothermic process. Bond energy is the amount of energy needed to break or form one mole of the bond. Complete the table and explain why the forward reaction is exothermic.



bond	bond energy kJ/mol	energy change kJ	exothermic or endothermic
$\text{N}\equiv\text{N}$	944	+944	endothermic
$\text{H}-\text{H}$	436	$3 \times 436 = +1308$	
$\text{N}-\text{H}$	388		

.....
 [3]

[Total: 13]