1 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
✗ = does not react

	metal			
aqueous solution	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.

$$Zn + Pb^{2+} \rightarrow Zn^{2+} + Pb$$

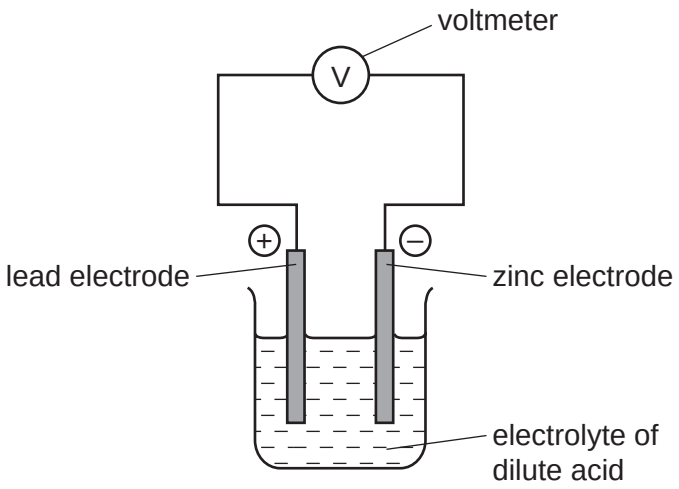
[2]

(iii) Complete the following ionic equation.

$$Zn + 2Ag^{+} \rightarrow \text{.....} + \text{.....}$$

[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]

[Total: 12]

2 Sulfuric acid and malonic acid are both dibasic acids. One mole of a dibasic acid can form two moles of hydrogen ions.

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

Dibasic acids can form salts of the type Na_2X and CaX.

(a) Malonic acid is a white crystalline solid which is soluble in water. It melts at 135 °C. The structural formula of malonic acid is given below. It forms salts called malonates.

$$CH_2(COOH)_2 \text{ or } HOOC-CH_2-COOH$$

(i) How could you determine if a sample of malonic acid is pure?

technique used .....

result if pure ..... [2]

(ii) What is the molecular formula of malonic acid?

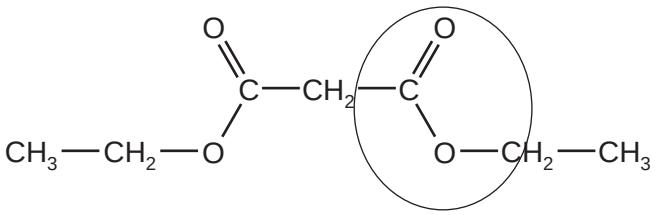
..... [1]

(iii) When malonic acid is heated there are two products, carbon dioxide and a simpler carboxylic acid. Deduce the name and molecular formula of this acid.

.....

..... [2]

(iv) Malonic acid reacts with ethanol to form a colourless liquid which has a 'fruity' smell. Its structural formula is given below.



What type of compound contains the group which is circled?

..... [1]

(b) **(i)** Suggest why a solution of malonic acid, concentration 0.2 mol / dm^3, has a higher pH than one of sulfuric acid of the same concentration.

..... [1]

(ii) Describe a test, other than measuring pH, which can be carried out on both acid solutions to confirm the explanation given in **(b)(i)** for the different pH values of the two acids.

.....

..... [2]

(c) Complete the following equations for reactions of these two acids.

(i) sodium hydroxide + malonic acid $\rightarrow$ ..... + ... [1]

.....

(ii) $CuO + H_2SO_4 \rightarrow$ ..... + ... [2]

(iii) $Mg + CH_2(COOH)_2 \rightarrow$ ..... + ... [2]

(iv) $K_2CO_3 + H_2SO_4 \rightarrow$ ..... + ... + ... [2]

[Total: 16]

3 Silver(I) chromate(VI) is an insoluble salt. It is prepared by precipitation.
20 cm^3 of aqueous silver(I) nitrate, concentration 0.2 mol/dm^3, was mixed with 20 cm^3 of aqueous potassium chromate(VI), concentration 0.1 mol/dm^3. After stirring, the mixture was filtered. The precipitate was washed several times with distilled water. The precipitate was then left in a warm oven for several hours.

$$2AgNO_3(aq) + K_2CrO_4(aq) \rightarrow Ag_2CrO_4(s) + 2KNO_3(aq)$$

(a) What difficulty arises if the name of a compound of a transition element does not include its oxidation state, for example iron oxide?

.....

..... [2]

(b) These questions refer to the preparation of the salt.

(i) Why is it necessary to filter the mixture after mixing and stirring?

..... [1]

(ii) What is the purpose of washing the precipitate?

..... [1]

(iii) Why leave the precipitate in a warm oven?

..... [1]

(c) Explain why the concentrations of silver(I) nitrate and potassium chromate(VI) are different.

..... [1]

(ii) What mass of silver(I) nitrate is needed to prepare 100 cm^3 of silver(I) nitrate solution, concentration 0.2 mol/dm^3?
The mass of one mole of $AgNO_3$ is 170 g.

.....

..... [2]

(iii) What is the maximum mass of silver(I) chromate(VI) which could be obtained from 20 cm^3 of aqueous silver(I) nitrate, concentration 0.2 mol/dm^3?

number of moles of $AgNO_3$ used = ... [1]

number of moles of Ag_2CrO_4 formed = ... [1]

mass of one mole of Ag_2CrO_4 = 332 g

mass of Ag_2CrO_4 formed = ... g [1]

[Total: 11]

4 Three ways of making salts are

- titration using a soluble base or carbonate
- neutralisation using an insoluble base or carbonate
- precipitation.

(a) Complete the following table of salt preparations.

method	reagent 1	reagent 2	salt
titration	....	....	sodium nitrate
neutralisation	nitric acid	....	copper(II) nitrate
precipitation	....	....	silver(I) chloride
neutralisation	sulfuric acid	zinc(II) carbonate	....

[6]

(b) Write an ionic equation with state symbols for the preparation of silver(I) chloride.

..... [2]

(ii) Complete the following equation.

$$ZnCO_3 + H_2SO_4 \rightarrow \text{.....} + \text{.....} + \text{.....}$$

[2]

[Total: 10]

5 A length of magnesium ribbon was added to 50 cm^3 of sulfuric acid, concentration 1.0 mol/dm^3. The time taken for the magnesium to react was measured. The experiment was repeated with the same volume of different acids. In all these experiments, the acid was in excess and the same length of magnesium ribbon was used.

(a)

experiment	acid	concentration in mol/dm^3	time / s
A	sulfuric acid	1.0	20
B	propanoic acid	0.5	230
C	hydrochloric acid	1.0	40
D	hydrochloric acid	0.5	80

(i) Write these experiments in order of reaction speed. Give the experiment with the fastest speed first.

..... [1]

(ii) Give reasons for the order you have given in **(i)**.

.....

.....

.....

.....

.....

..... [5]

(b) Suggest **two** changes to experiment C which would increase the speed of the reaction and explain why the speed would increase. The volume of the acid, the concentration of the acid and the mass of magnesium used were kept the same.

change 1 .....

explanation .....

.....

change 2 .....

explanation .....

..... [5]

[Total: 11]

6 Ethylamine, $CH_3–CH_2–NH_2$, is a base which has similar properties to ammonia.

(a) In aqueous ethylamine, there is the following equilibrium.

$$CH_3–CH_2–NH_2 + H_2O \rightleftharpoons CH_3–CH_2–NH_3^+ + OH^-$$

Explain why water is behaving as an acid in this reaction.

..... [1]

(b) Given aqueous solutions of ethylamine and sodium hydroxide, describe how you could show that ethylamine is a weak base like ammonia and not a strong base like sodium hydroxide.

.....

.....

..... [3]

(c) Ethylamine, like ammonia, reacts with acids to form salts.

$$CH_3–CH_2–NH_2 + HCl \rightarrow CH_3–CH_2–NH_3Cl$$

ethylammonium chloride

Suggest how you could displace ethylamine from the salt, ethylammonium chloride.

.....

..... [2]

(d) Explain the chemistry of the following reaction:

When aqueous ethylamine is added to aqueous iron(III) chloride, a brown precipitate is formed.

.....

..... [2]

[Total: 8]