

1 What is the electronic configuration for the particle  ${}_{13}^{27}\text{Al}^{+}$ ?

- A**  $1s^2 2s^2 2p^6 3s^1 3p^1$   
**B**  $1s^2 2s^2 2p^6 3s^2$   
**C**  $1s^2 2s^2 2p^6 3s^2 3p^2$   
**D**  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^1$

2 The data in the table gives the 5th to the 10th ionisation energies of three elements from Period 3 of the Periodic Table.

| element | ionisation energy / $\text{kJ mol}^{-1}$ |        |        |        |        |        |
|---------|------------------------------------------|--------|--------|--------|--------|--------|
|         | 5th                                      | 6th    | 7th    | 8th    | 9th    | 10th   |
| X       | 6274                                     | 21 269 | 25 398 | 29 855 | 35 868 | 40 960 |
| Y       | 7012                                     | 8 496  | 27 107 | 31 671 | 36 579 | 43 140 |
| Z       | 6542                                     | 9 362  | 11 018 | 33 606 | 38 601 | 43 963 |

What are the correct identities of these three elements?

|          | element X | element Y | element Z |
|----------|-----------|-----------|-----------|
| <b>A</b> | Na        | Mg        | Al        |
| <b>B</b> | Mg        | Al        | Si        |
| <b>C</b> | P         | S         | Cl        |
| <b>D</b> | S         | Cl        | Ar        |

1 What is the electrons in boxes notation for the  $\text{Fe}^{3+}$  ion?

- A** [Ar] 

|    |   |  |  |  |
|----|---|--|--|--|
| ↑↓ | ↑ |  |  |  |
|----|---|--|--|--|

|    |
|----|
| ↑↓ |
|----|
- B** [Ar] 

|   |   |   |  |  |
|---|---|---|--|--|
| ↑ | ↑ | ↑ |  |  |
|---|---|---|--|--|

|    |
|----|
| ↑↓ |
|----|
- C** [Ar] 

|    |   |   |   |  |
|----|---|---|---|--|
| ↑↓ | ↑ | ↑ | ↑ |  |
|----|---|---|---|--|

|  |
|--|
|  |
|--|
- D** [Ar] 

|   |   |   |   |   |
|---|---|---|---|---|
| ↑ | ↑ | ↑ | ↑ | ↑ |
|---|---|---|---|---|

|  |
|--|
|  |
|--|

- 1 Helium forms an ion  ${}^3_2\text{He}^+$ .

Three statements about this ion are listed.

- 1 It contains two protons.
- 2 It contains three neutrons.
- 3 It contains one electron.

Which statements are correct?

- A** 1, 2 and 3      **B** 1 and 3 only      **C** 2 and 3 only      **D** 2 only

- 2 The table shows the first five ionisation energies of element X.

| element | ionisation energy / $\text{kJ mol}^{-1}$ |      |      |        |        |
|---------|------------------------------------------|------|------|--------|--------|
|         | 1st                                      | 2nd  | 3rd  | 4th    | 5th    |
| X       | 736                                      | 1450 | 7740 | 10 500 | 13 600 |

Element X is in Period 3 of the Periodic Table.

What is element X?

- A** sodium  
**B** magnesium  
**C** silicon  
**D** argon

**1** Manganese, Mn, and its compounds are widely used in many chemical reactions.

**(a)** Mn is usually found as a single isotope, manganese-55.

**(i)** Determine the number of protons, neutrons and electrons in an atom of manganese-55.

number of protons ..... neutrons ..... electrons .....  
[1]

**(ii)** Define isotopes.

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

**(iii)** A sample of manganese from the Moon is found to contain manganese-53 in addition to manganese-55.

State the two pieces of information needed to determine the relative atomic mass,  $A_r$ , of manganese in this sample.

1 .....  
2 .....  
[2]

**(b)** The shorthand electronic configuration of manganese is  $[\text{Ar}] 3d^5 4s^2$ .

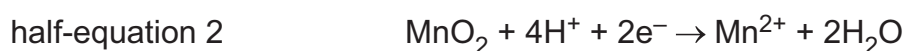
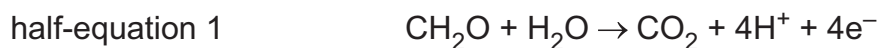
**(i)** Complete the full electronic configuration of manganese.

.....  $3d^5 4s^2$  [1]

**(ii)** Deduce the total number of unpaired electrons in an atom of manganese.

..... [1]

- (c) Manganese(IV) oxide reacts with methanal,  $\text{CH}_2\text{O}$ , in acidic conditions to produce carbon dioxide. The movement of electrons to or from relevant species is shown in the following half-equations.



- (i) Identify the species that is reduced in half-equation 2. Explain your answer.

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

- (ii) The oxidation state of carbon in methanal is 0.

Calculate the oxidation state of carbon in carbon dioxide.

..... [1]

- (iii) Construct the ionic equation for the reaction of manganese(IV) oxide with methanal in acidic conditions.

..... [2]

[Total: 10]

**1** Chromium, Cr, and its compounds are widely used in many chemical reactions.

**(a)** Cr exists as four stable isotopes.

**(i)** The most common isotope of Cr is chromium-52.

Determine the number of protons, neutrons and electrons in an atom of chromium-52.

number of protons ..... neutrons ..... electrons ..... [1]

**(ii)** Describe how an atom of chromium-54 differs from an atom of chromium-52. Refer to numbers of particles in your answer.

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

**(iii)** The relative isotopic masses of the isotopes of Cr can be determined using mass spectrometry.

State what other information is needed to calculate the relative atomic mass,  $A_r$ , of Cr.

..... [1]

**(iv)** Atoms of  $^{52}\text{Cr}$ ,  $^{53}\text{Cr}$  and  $^{54}\text{Cr}$  make up more than 95% of naturally occurring chromium atoms. The  $A_r$  of naturally occurring Cr is 51.996.

Suggest what these statements imply about the relative isotopic mass of the fourth stable isotope of chromium.

..... [1]

**(b)** The shorthand electronic configuration of chromium is  $[\text{Ar}] 3d^5 4s^1$ .

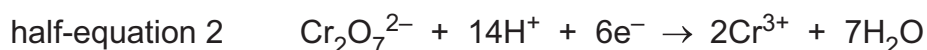
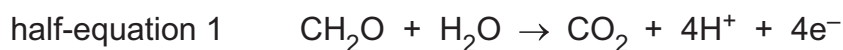
**(i)** Complete the full electronic configuration of chromium.

.....  $3d^5 4s^1$  [1]

**(ii)** Deduce the total number of unpaired electrons in an atom of chromium.

..... [1]

- (c) Acidified dichromate(VI) ions will convert methanal,  $\text{CH}_2\text{O}$ , to carbon dioxide. The movement of electrons to or from relevant species is shown in the following half-equations.



- (i) Identify the species that is reduced in half-equation 2. Explain your answer.

..... [1]

- (ii) The oxidation state of the carbon atom in methanal is 0.

Calculate the oxidation state of carbon in carbon dioxide.

..... [1]

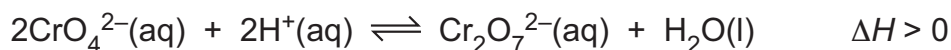
- (iii) Construct the ionic equation for the reaction of dichromate(VI) ions with methanal in acidic conditions.

..... [2]

- (iv) Methanal is a liquid at  $-30^\circ\text{C}$  but carbon dioxide is a gas at this temperature. Explain why.

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

- (d) In acidic conditions, a dynamic equilibrium is established between  $\text{CrO}_4^{2-}(\text{aq})$  and  $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ .



- (i) State what is meant by dynamic equilibrium.

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

- (ii) Identify the condition necessary to establish dynamic equilibrium.

..... [1]

- (iii)  $\text{CrO}_4^{2-}(\text{aq})$  ions are yellow and  $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$  ions are orange.

State what is observed when the following changes are made to an equilibrium mixture of acidified  $\text{CrO}_4^{2-}(\text{aq})$  and  $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$  ions.

Explain your answers.

- The equilibrium mixture is warmed gently.

observation .....

explanation .....

.....

.....

- Dilute  $\text{HCl}(\text{aq})$  is added to the equilibrium mixture.

observation .....

explanation .....

.....

.....

[4]

- (e) Chromium(IV) fluoride,  $\text{CrF}_4$ , is a covalent molecule that shows similar chemical properties to  $\text{SiCl}_4$ .

Suggest the type of reaction that occurs when  $\text{CrF}_4$  is placed in water.

Construct a relevant equation for this reaction.

type of reaction .....

equation .....

[2]