

Y12 Chemistry Homework Book 1

Physical and Inorganic Chemistry

Name:

Teacher:

GCSE Transition

What grade did you get?

What are your ambitions for after 6th form?

What topics did you find the most difficult?



1 Complete the table to show the formula and structure type (use ✓s) of the following substances.

(10)

| Substance | Formula | Monatomic | Simple molecular | Giant covalent | Ionic | Metallic |
|-------------------|---------|-----------|------------------|----------------|-------|----------|
| silver(I) nitrate | | | | | | |
| bromine | | | | | | |
| potassium bromide | | | | | | |
| calcium | | | | | | |
| aluminium sulfate | | | | | | |
| argon | | | | | | |
| ammonia | | | | | | |
| ammonium chloride | | | | | | |
| hydrogen sulfide | | | | | | |
| graphene | | | | | | |

2 a) Explain what the Avogadro constant is.

.....
.....
..... (1)

b) Calculate the number of molecules of water in 90.0 g of water. (Avogadro constant, $L = 6.022 \times 10^{23} \text{ mol}^{-1}$)

.....
.....
.....
.....
..... (2)

3 Calculate the relative formula mass (M_r) of the following substances.

a) O_2 (1)

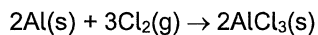
b) K_2SO_4 (1)

c) $\text{Mg}(\text{NO}_3)_2$ (1)

d) $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ (1)

- 4** Calculate the mass of each of the following.
- a) 5.00 moles of Fe_2O_3 (1)
- b) 0.250 moles of hydrogen (1)
- c) 1.50×10^{-4} moles of aluminium iodide (1)
- 5** Calculate the number of moles of each of the following.
- a) 23.6 g of Cu (1)
- b) 43.8 mg of fluorine (1)
- c) 1.25 tonnes of vanadium(V) oxide (1)
- 6** Convert these quantities into the units shown.
- a) 18 mmol to mol (1)
- b) 20 MPa to Pa (1)
- c) 65 mg to g (1)
- d) 20°C to K (1)
- e) 125 pm to m (1)
- f) 50 cm^3 to dm^3 (1)
- g) 200 cm^3 to m^3 (1)
- 7** 250 cm^3 of aqueous solution contains 2.0 g of dissolved sodium hydroxide. Calculate the concentration of the solution in mol dm^{-3} (2)
- 8** What mass of oxygen reacts with 2.30 g of sodium? $4\text{Na(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{Na}_2\text{O(s)}$ (3)

- 9 Which is the limiting reagent and what mass of aluminium chloride is formed when 1.35 g of aluminium is heated with 4.26 g of chlorine?



.....

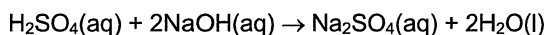
.....

.....

.....

..... (4)

- 10 In a titration, it was found that 25.0 cm³ of 0.150 mol dm⁻³ sulfuric acid reacts with 23.58 cm³ of sodium hydroxide solution. Calculate the concentration of the sodium hydroxide solution in mol dm⁻³.



.....

.....

.....

.....

.....

..... (3)

- 11 Write a balanced equation for each of these reactions. (6)

a) calcium + water

.....

b) ethanethiol (C₂H₅SH) + oxygen

.....

c) zinc + hydrochloric acid

.....

d) potassium carbonate + nitric acid

.....

e) ammonia + sulfuric acid

.....

f) copper(II) oxide + nitric acid

.....

12 Write an ionic equation for each of these reactions. (3)

- a) precipitation of iron(III) hydroxide when solutions of sodium hydroxide and iron(III) nitrate are mixed

.....

- b) redox reaction between solution of silver(I) nitrate and magnesium metal

.....

- c) acid-base reaction between sulfuric acid and potassium hydroxide

.....

13 Complete the table about these atoms and ions. (4)

| atom / ion | atomic number | mass number | protons | neutrons | electrons |
|---------------------------|---------------|-------------|---------|----------|-----------|
| $^{37}_{17}\text{Cl}$ | | | | | |
| $^{37}_{17}\text{Cl}^{-}$ | | | | | |
| | | | 12 | 14 | 10 |
| | 8 | 18 | | | 10 |

| Area | Strength | To develop | Area | Strength | To develop | Area | Strength | To develop |
|---------------------------------|----------|------------|---------------------------------------|----------|------------|--|----------|------------|
| Done with care and thoroughness | | | Write formulae (ionic) | | | Find moles from mass (and vice versa) | | |
| Good SPG | | | Write formulae (other) | | | Can do reacting mass calculations | | |
| Shows full working | | | Write balanced equations | | | Understands limiting reagents | | |
| Explanations are clear | | | Write ionic equations | | | Can do solution calculations | | |
| Convert units | | | Identify structure type of substances | | | Can work out PNE numbers in atoms/ions | | |
| Work to appropriate sig figs | | | Understands Avogadro constant | | | | | |
| Gives units when appropriate | | | Can work out formula mass | | | | | |



1 Complete the table using ✓s to show which type of structure the following substances have.

(8)

| Substance | Monatomic | Simple molecular | Giant covalent | Ionic | Metallic |
|--|-----------|------------------|----------------|-------|----------|
| helium (He) | | | | | |
| nitrogen fluoride (NF ₃) | | | | | |
| silicon chloride (SiCl ₄) | | | | | |
| strontium chloride (SrCl ₂) | | | | | |
| iron oxide (Fe ₂ O ₃) | | | | | |
| phosphorus (P ₄) | | | | | |
| silicon dioxide (SiO ₂) | | | | | |
| iridium (Ir) | | | | | |

2 Give the formula of each of the following ionic substances.

(8)

- | | |
|------------------------------|-------------------------------|
| a) potassium bromide | e) cobalt(II) carbonate |
| b) aluminium sulfide | f) ammonium nitrate |
| c) magnesium hydroxide | g) titanium(IV) oxide |
| d) iron(III) nitrate | h) rubidium sulfate |

3 Write a balanced equation for each of these reactions.

(10)

- a) potassium oxide + hydrochloric acid

.....

- b) barium + water

.....

- c) propane (C₃H₈) + oxygen

.....

- d) magnesium + nitric acid

.....

- e) zinc(II) carbonate + sulfuric acid

.....

4 Write an ionic equation for each of these reactions. (3)

a) redox reaction between solution of copper(II) sulfate and magnesium metal

.....

b) acid-base reaction between nitric acid and calcium hydroxide

.....

c) precipitation of silver(I) bromide when solutions of potassium bromide and silver(I) nitrate are mixed

.....

5 Convert these quantities into the units shown.

a) 25 cm³ to m³ (1)

b) 150 cm³ to dm³ (1)

c) 40 MPa to Pa (1)

d) 7.5 mg to g (1)

6 6.15 g of hydrated magnesium sulfate, MgSO₄.xH₂O decompose to form 3.00 g of anhydrous magnesium sulfate on heating. Calculate the formula mass of hydrated magnesium sulfate and the value of x.

.....

.....

.....

.....

.....

.....

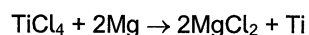
.....

.....

.....

..... (4)

7 Determine the limiting reagent and then calculate the mass of titanium produced when 10.00 g of titanium chloride react with 2.00 g of magnesium.



.....

.....

.....

.....

.....

.....

..... (4)

8 Describe what each of the following formulae tells you about the substance shown.

- a) Ammonia has the molecular formula NH_3
.....
..... (2)
- b) Silicon dioxide has the formula SiO_2
.....
..... (2)
- c) Aluminium oxide has the formula Al_2O_3
.....
..... (2)
- d) Sulfur has the molecular formula S_8
.....
..... (2)

9 The element carbon exists in several different forms (allotropes), including diamond, graphite and graphene.

- a) Explain why these forms of carbon all have high melting points.
.....
.....
.....
.....
..... (3)
- b) Explain why graphite and graphene are electrical conductors but diamond is not.
.....
.....
.....
.....
..... (3)

- c) Buckminsterfullerene is another form of carbon with the formula C_{60} . Explain how the formula C_{60} tells us that this is a molecular substance and not a giant covalent substance.

.....

.....

.....

.....

.....

..... (2)

| Area | Strength | To develop | Area | Strength | To develop | Area | Strength | To develop |
|---------------------------------|----------|------------|---------------------------------------|----------|------------|--|----------|------------|
| Done with care and thoroughness | | | Write formulae (ionic) | | | Understands limiting reagents | | |
| Good SPG | | | Write formulae (other) | | | What formulas mean | | |
| Shows full working | | | Write balanced equations | | | Link structure types to properties | | |
| Explanations are clear | | | Write ionic equations | | | Identify structure types of substances | | |
| Convert units | | | Can work out formula mass | | | | | |
| Work to appropriate sig figs | | | Find moles from mass (and vice versa) | | | | | |
| Gives units when appropriate | | | Can do reacting mass calculations | | | | | |

Doddle quiz homework:

Formulae and equations

Score:

Use this page for any rough work. If there are any things you need help with, write them here and ask your teacher!

Atomic Structure and Periodicity

3.1.1 Atomic Structure

| |
|---|
| T 1. Appreciate that knowledge and understanding of atomic structure has evolved over time. |
| T 2. Protons, neutrons and electrons: relative charge and relative mass. |
| T 3. An atom consists of a nucleus containing protons and neutrons surrounded by electrons. |
| T 4. Determine the number of fundamental particles in atoms and ions using mass number, atomic number and charge |
| T 5. Explain the existence of isotopes. |
| T 6. Interpret simple mass spectra of elements |
| T 7. Calculate relative atomic mass from isotopic abundance, limited to mononuclear ions. |
| T 8. Define first ionisation energy |
| T 9. Write equations for first and successive ionisation energies |
| T 10. Explain how first and successive ionisation energies in Period 3 (Na–Ar) and in Group 2 (Be–Ba) give evidence for electron configuration in sub-shells and in shells. |

Periodicity

| |
|--|
| T 1. An element is classified as s, p, d or f block according to its position in the Periodic Table, which is determined by its proton number. |
| T 2. Explain the trends in atomic radius and first ionisation energy |
| T 3. Explain the melting point of the elements in terms of their structure and bonding. |

Exam booklet reflection:

WWW

EBI

Checked by teacher

Doddle quiz homework:

Atomic Structure

Score:

Electron arrangement

Score:

Periodicity

Score:

AS LEVEL CHEMISTRY

TOPIC 1 – ATOMIC STRUCTURE AND THE PERIODIC TABLE TEST

Answer all questions

Max 50 marks

| | | | |
|------|----------|--------|-------------|
| Name | | | |
| Mark |/50 |% | Grade |

SECTION A

Table 1 shows some data about fundamental particles in an atom.

Table 1

| Particle | Proton | neutron | electron |
|----------|--------------------------|--------------------------|--------------------------|
| Mass / g | 1.6725×10^{-24} | 1.6748×10^{-24} | 0.0009×10^{-24} |

- (i) An atom of hydrogen can be represented as ${}^1\text{H}$

Use data from **Table 1** to calculate the mass of this hydrogen atom.

.....

(1)

- (ii) Which **one** of the following is a fundamental particle that would **not** be deflected by an electric field?

A electron

B neutron

C proton

Write the correct letter, **A**, **B** or **C**, in the box.

(1)
(Total 2 marks)

2. (a) Complete the following table.

| Particle | Relative charge | Relative mass |
|----------|-----------------|---------------|
| Proton | | |
| Neutron | | |
| Electron | | |

(3)

- (b) An atom of element **Z** has two more protons and two more neutrons than an atom of $^{34}_{16}\text{S}$. Give the symbol, including mass number and atomic number, for this atom of **Z**.

.....

(2)

- (c) Complete the electronic configurations for the sulphur atom, S, and the sulphide ion, S^{2-} .

S $1s^2$

S^{2-} $1s^2$

(2)

- (d) State the block in the Periodic Table in which sulphur is placed and explain your answer.

Block

Explanation

(2)

(Total 9 marks)

3. (a) One isotope of sodium has a relative mass of 23.

(i) Define, in terms of the fundamental particles present, the meaning of the term *isotopes*.

.....

.....

(ii) Explain why isotopes of the same element have the same chemical properties.

.....

.....

(3)

(b) Give the electronic configuration, showing all sub-levels, for a sodium atom.

.....

(1)

(c) Explain why chromium is placed in the d block in the Periodic Table.

.....

.....

(1)

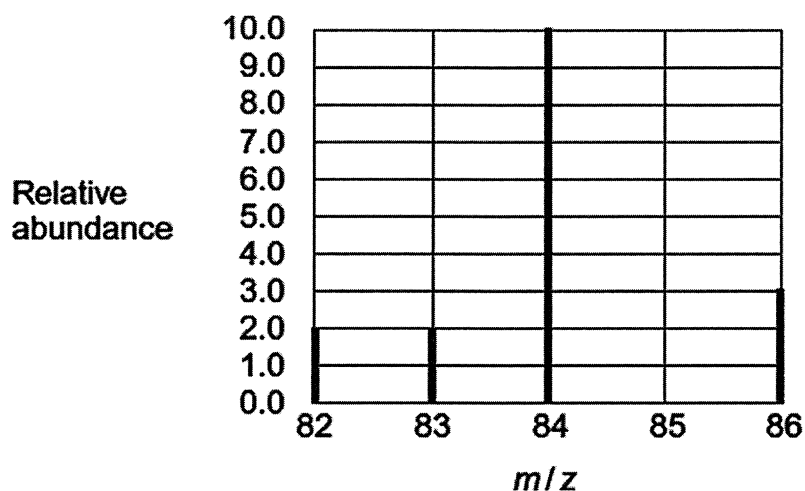
(d) An atom has half as many protons as an atom of ^{28}Si and also has six fewer neutrons than an atom of ^{28}Si . Give the symbol, including the mass number and the atomic number, of this atom.

.....

(2)

(Total 7 marks)

4. The mass spectrum of a sample of krypton taken from a meteorite is shown below.



- (a) Use this spectrum to calculate the relative atomic mass of this sample of krypton. Give your answer to one decimal place.

Explain why the value you have calculated is slightly different from the relative atomic mass given in the Periodic Table.

.....

.....

.....

.....

.....

(4)

- (b) State how krypton is ionised in the mass spectrometer.

Write an equation, including state symbols, to show the reaction that occurs when the **first** ionisation energy of Kr is measured.

Sometimes the mass spectrum of Kr has a very small peak with an m/z value of 42. Explain the occurrence of this peak.

.....

.....

.....

.....

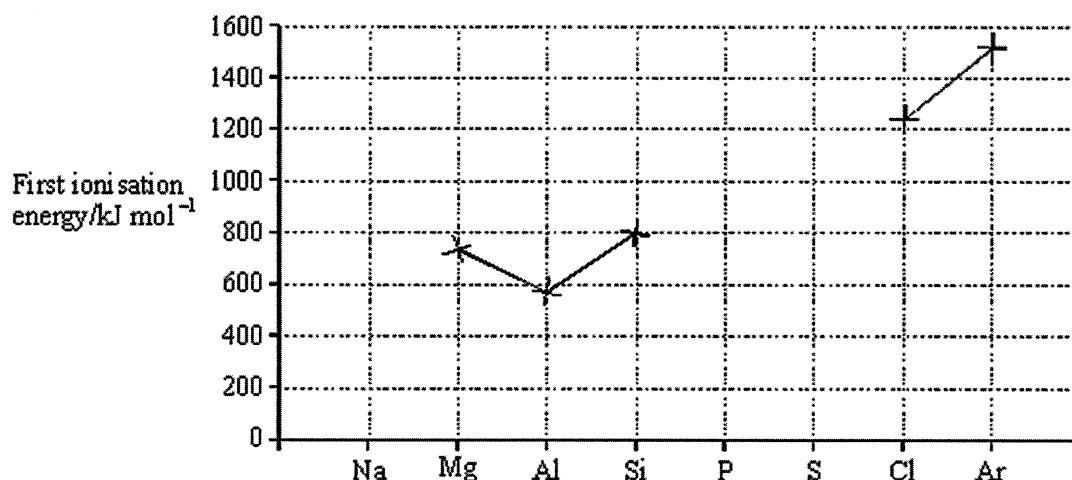
.....

.....

(5)

(Total 9 marks)

5. The diagram below shows the values of the first ionisation energies of some of the elements in Period 3.



- (a) On the above diagram, use crosses to mark the approximate positions of the values of the first ionisation energies for the elements Na, P and S. Complete the diagram by joining the crosses.
- (b) Explain the general increase in the values of the first ionisation energies of the elements Na–Ar.

(3)

.....

.....

.....

.....

(3)

- (c) In terms of the electron sub-levels involved, explain the position of aluminium and the position of sulphur in the diagram.

Explanation for aluminium

.....

.....

Explanation for sulphur

.....

.....

(4)
(Total 10 marks)

6. This question is about the first ionisation energies of some elements in the Periodic Table.

- (a) Write an equation, including state symbols, to show the reaction that occurs when the first ionisation energy of lithium is measured.

.....

(1)

- (b) State and explain the general trend in first ionisation energies for the Period 3 elements aluminium to argon.

Trend

Explanation

.....

.....

(3)

- (c) There is a similar general trend in first ionisation energies for the Period 4 elements gallium to krypton.

State how selenium deviates from this general trend and explain your answer.

How selenium deviates from this trend

Explanation

.....

.....

(Extra space).....

(3)

- (d) Suggest why the first ionisation energy of krypton is lower than the first ionisation energy of argon.

.....

.....

.....

(1)

- (e) The table below gives the successive ionisation energies of an element.

| | First | Second | Third | Fourth | Fifth |
|--|-------|--------|-------|--------|-------|
| Ionisation energy / kJ mol ⁻¹ | 590 | 1150 | 4940 | 6480 | 8120 |

Deduce the group in the Periodic Table that contains this element.

.....

(1)

- (f) Identify the element that has a 5+ ion with an electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$

.....

(1)
(Total 10 marks)

SECTION B

7. Which one of the following ionisations requires less energy than the first ionisation energy of oxygen?

- A $S(g) \rightarrow S^+(g) + e^-$
- B $O^+(g) \rightarrow O^{2+}(g) + e^-$
- C $N(g) \rightarrow N^+(g) + e^-$
- D $F(g) \rightarrow F^+(g) + e^-$

(Total 1 mark)

8. Which one of the following explains why boron has a lower first ionisation energy than beryllium?

- A A boron atom is smaller than a beryllium atom.
- B In beryllium all the electrons are paired in full sub-shells.
- C A beryllium atom has fewer protons than a boron atom.
- D In boron the $2p$ electron occupies a higher energy level than a $2s$ electron.

(Total 1 mark)

9. Chlorine has two isotopes, ^{35}Cl and ^{37}Cl . The number of molecular ion peaks in the mass spectrum of a sample of Cl_2 is

- A 2
- B 3
- C 4
- D 5

(Total 1 mark)

Calculations

| Amount of substance |
|---|
| T 1. Define relative atomic mass (A_r) |
| T 2. Define relative molecular mass (M_r). |
| T 3. Carry out calculations using the Avogadro constant |
| T 4. Carry out calculations using mass of substance, M_r , and amount in moles |
| T 5. Carry out calculations using concentration, volume and amount of substance in a solution. |
| T 6. Students should be able to use the ideal gas equation in calculations. |
| T 7. Calculate empirical formula from data giving composition by mass or percentage by mass |
| T 8. calculate molecular formula from the empirical formula and relative molecular mass. |
| T 9. balance equations for unfamiliar reactions when reactants and products are specified. |
| T 10. Use balanced equations to calculate masses |
| T 11. Use balanced equations to calculate volumes of gases |
| T 12. Use balanced equations to calculate percentage yield |
| T 13. Use balanced equations to calculate percentage atom economies |
| T 14. Use balanced equations to calculate concentrations and volumes for reactions in solutions |

Exam booklet reflection:

WWW

EBI

Checked by teacher

Doddle quiz homework:

Amount of substance 1 **Score:**

Amount of substance 2 **Score:**

AS LEVEL CHEMISTRY

TOPIC 2 – AMOUNT OF SUBSTANCE TEST

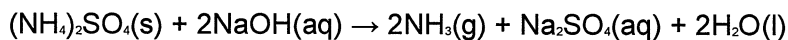
Answer all questions

Max 50 marks

| | | | |
|------|----------|--------|-------------|
| Name | | | |
| Mark |/50 |% | Grade |

SECTION A

1. Ammonium sulfate reacts with sodium hydroxide to form ammonia, sodium sulfate and water as shown in the equation below.



- (a) A 3.14 g sample of ammonium sulfate reacted completely with 39.30 cm³ of a sodium hydroxide solution.

- (i) Calculate the amount, in moles, of (NH₄)₂SO₄ in 3.14 g of ammonium sulfate.

.....
.....
.....

(2)

- (ii) Hence calculate the amount, in moles, of sodium hydroxide which reacted.

.....

(1)

- (iii) Calculate the concentration, in mol dm⁻³, of the sodium hydroxide solution used.

.....
.....

(1)

- (b) Calculate the percentage atom economy for the production of ammonia in the reaction between ammonium sulfate and sodium hydroxide.

.....
.....
.....

(2)

- (c) Ammonia is manufactured by the Haber Process.



Calculate the percentage atom economy for the production of ammonia in this process.

.....
.....

(1)

- (d) A sample of ammonia gas occupied a volume of $1.53 \times 10^{-2} \text{ m}^3$ at 37°C and a pressure of 100 kPa.
(The gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)

Calculate the amount, in moles, of ammonia in this sample.

.....

(3)

- (e) Glauber's salt is a form of hydrated sodium sulfate that contains 44.1% by mass of sodium sulfate. Hydrated sodium sulfate can be represented by the formula $\text{Na}_2\text{SO}_4 \cdot x\text{H}_2\text{O}$ where x is an integer. Calculate the value of x .

.....

(3)

(Total 13 marks)

2. Norgessaltpeter decomposes on heating as shown by the following equation.



A sample of Norgessaltpeter was decomposed completely.

The gases produced occupied a volume of $3.50 \times 10^{-3} \text{ m}^3$ at a pressure of 100 kPa and a temperature of 31°C .

(The gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)

- (i) Calculate the total amount, in moles, of gases produced.

.....

(3)

- (ii) Hence calculate the amount, in moles, of oxygen produced.

.....

(1)

(Total 4 marks)

3. Potassium carbonate can also occur as a hydrated compound, $\text{K}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$. Analysis of this hydrated compound showed that it contained 11.5% by mass of water. Determine the value of x . Show your working.

.....

.....

.....

.....

.....

.....

(Total 2 marks)

4. The element nitrogen forms compounds with metals and non-metals.

- (a) Calcium nitride contains 81.1% by mass of the metal. Calculate the empirical formula of calcium nitride. Show your working.

.....

.....

.....

.....

.....

.....

(3)

- (b) Write an equation for the reaction between silicon and nitrogen to form silicon nitride, Si_3N_4

.....

(1)
(Total 4 marks)

5. The correct technique can improve the accuracy of a titration.
- (a) State why it is important to fill the space below the tap in the burette with solution A before beginning an accurate titration.

.....
.....

(1)

- (b) Suggest **one** reason why a 250 cm³ conical flask is preferred to a 250 cm³ beaker for a titration.

.....
.....

(1)

- (c) During a titration, a chemist rinsed the inside of the conical flask with deionised water. The water used for rinsing remained in the conical flask.

- (i) Give **one** reason why this rinsing can improve the accuracy of the end-point.

.....
.....
.....

(1)

- (ii) Explain why the water used for rinsing has **no** effect on the accuracy of the titre.

.....
.....

(1)

- (d) Suggest **one** reason why repeating a titration makes the value of the average titre more reliable.

.....
.....

(1)

(Total 5 marks)

6. (a) Sodium hydrogencarbonate (NaHCO_3) can also be used to neutralise ethanoic acid spillages. The equation for this reaction is shown below.



State the ideal gas equation.

.....

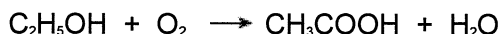
(1)

- (b) There are several methods by which ethanoic acid is synthesised on an industrial scale. One method is the oxidation of butane in the presence of metal ion catalysts. Balance the equation given below which summarises this reaction.



(1)

- (c) A second method by which ethanoic acid is synthesised involves the oxidative fermentation of ethanol in the presence of bacteria. The equation representing this reaction is given below.



In a small scale experiment using this second method it was found that 23.0 g of ethanol produced only 4.54 g of ethanoic acid. Calculate the percentage yield for this experiment.

.....

.....

.....

(2)

(Total 4 marks)

7. Indium forms a compound X with hydrogen and oxygen. Compound X contains 69.2% indium and 1.8% hydrogen by mass. Calculate the empirical formula of compound X.

.....

.....

.....

.....

(3)

(Total 3 marks)

8. (a) The manufacturer of vinegar buys concentrated ethanoic acid as a 15.0 mol dm^{-3} solution. In case of an accidental spillage of this ethanoic acid the manufacturer always has sodium carbonate readily available to neutralise the acid. The equation for this reaction is shown below.



- (i) Calculate the amount, in moles, of ethanoic acid in 10.0 cm^3 of a 15.0 mol dm^{-3} solution.

.....

(1)

- (ii) Use your answer from part (i) to calculate the amount, in moles, of sodium carbonate needed to react completely with this amount of ethanoic acid.

.....

(1)

- (iii) Use data from the Periodic Table to calculate the relative formula mass of sodium carbonate. Give your answer to the appropriate precision.

.....

(1)

- (iv) Use your answers from parts (ii) and (iii) to determine the minimum mass of sodium carbonate needed to react completely with 10.0 cm^3 of the 15.0 mol dm^{-3} solution of ethanoic acid.

.....

(1)

- (b) State **one** hazard when using concentrated ethanoic acid and **one** safety precaution you would take to minimise this hazard.

Hazard

Precaution

.....

(1)

(Total 5 marks)

9. (a) A solution of barium hydroxide is often used for the titration of organic acids. A suitable indicator for the titration is thymol blue. Thymol blue is yellow in acid and blue in alkali. In a titration a solution of an organic acid was added from a burette to a conical flask containing 25.0 cm³ of a barium hydroxide solution and a few drops of thymol blue.

(i) Describe in full the colour change at the end-point of this titration.

.....

(1)

(ii) Thymol blue is an acid. State how the average titre would change if a few cm³, rather than a few drops, of the indicator were used by mistake in this titration.

.....

(1)

(iii) Barium hydroxide is toxic. Suggest **one** safety precaution you would take to minimise this hazard when wiping up a spillage of barium hydroxide solution.

.....

.....

(1)

(iv) Suggest **one** reason why a 250 cm³ conical flask is preferred to a 250cm³ beaker for a titration.

.....

.....

(1)

(v) Suggest **one** reason why repeating a titration can improve its reliability

.....

.....

(1)

- (b) Solubility data for barium hydroxide and calcium hydroxide are given in the table below.

| Compound | Solubility at 20 °C / g dm ⁻³ |
|-------------------|--|
| barium hydroxide | 38.9 |
| calcium hydroxide | 1.73 |

- (i) Use the data given in the table to calculate the concentration, in mol dm⁻³, of a saturated solution of calcium hydroxide ($M_r = 74.1$) at 20°C.

.....

.....

(1)

- (ii) Suggest **one** reason why calcium hydroxide solution is **not** used in the titration of a 0.200 mol dm⁻³ solution of an acid.

.....

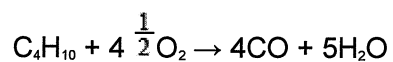
.....

(1)

(Total 7 marks)

SECTION B

10. An equation for the incomplete combustion of butane in oxygen is



The volume in dm³ of oxygen at 295 K and 100 kPa required to burn 0.1 mol of butane to form steam and carbon monoxide only is

- A 8.6
- B 11
- C 12
- C 16

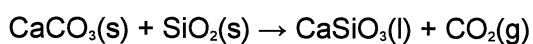
(Total 1 mark)

11. Silver oxide, Ag₂O, can be reduced by passing hydrogen gas over the heated oxide. The maximum mass of silver that could be obtained from 2.32 g of silver oxide is

- A 2.02 g
- B 2.06 g
- C 2.12 g
- D 2.16 g

(Total 1 mark)

12. The removal of silicon dioxide with limestone in the Blast Furnace can be represented by the following equation.



The volume of carbon dioxide, measured at 298 K and 1.01×10^5 Pa, formed in this reaction during the removal of 1.00 tonne (1000 kg) of silicon dioxide is

- A 24.5 dm³
- B 408 dm³
- C 24.5 m³
- D 408 m³

(Total 1 mark)

Equilibria and Kinetics

Chemical Equilibria

T 1. Use Le Chatelier's principle to predict qualitatively the effect of changes in temperature, pressure and concentration on the position of equilibrium

T 2. Explain why, for a reversible reaction used in an industrial process, a compromise temperature and pressure may be used.

T 3. Construct an expression for K_c for a homogeneous system in equilibrium

T 4. Calculate a value for K_c from the equilibrium concentrations for a homogeneous system at constant temperature

T 5. Perform calculations involving K_c

Kinetics

T 1. Define the term activation energy

T 2. Explain why most collisions do not lead to a reaction.

T 3. Draw and interpret Maxwell-Boltzmann distribution curves for different temperatures.

T 4. Use the Maxwell-Boltzmann distribution to explain why a small temperature increase can lead to a large increase in rate.

T 5. Explain how a change in concentration or a change in pressure influences the rate of a reaction.

T 6. Use a Maxwell-Boltzmann distribution to help explain how a catalyst increases the rate of a reaction involving a gas.

Exam booklet reflection:

WWW

EBI

Checked by teacher

Doddle quiz homework:

Kinetics

Score:

Analysis and evaluating results

Score:

Measurements and data presentation Score:

AS LEVEL CHEMISTRY

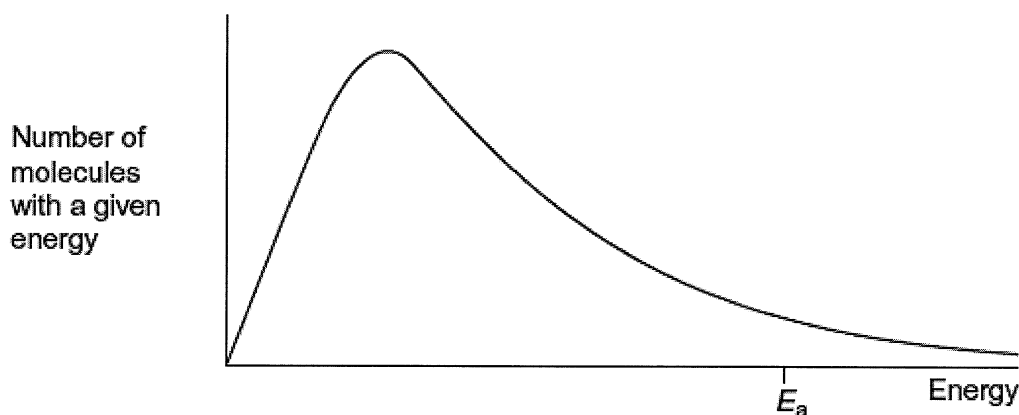
TOPIC 5 – HOW FAR HOW FAST? TEST

Answer all questions

Max 50 marks

| | | | |
|------|----------|--------|-------------|
| Name | | | |
| Mark |/50 |% | Grade |

1. The diagram below shows a Maxwell–Boltzmann distribution for a sample of gas at a fixed temperature. E_a is the activation energy for the decomposition of this gas.



- (a) (i) On this diagram, sketch the distribution for the same sample of gas at a higher temperature.
- (ii) With reference to the Maxwell–Boltzmann distribution, explain why an increase in temperature increases the rate of a chemical reaction.

(2)

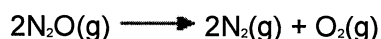
.....

.....

.....

(2)

- (b) Dinitrogen oxide (N_2O) is used as a rocket fuel. The data in the table below show how the activation energy for the decomposition of dinitrogen oxide differs with different catalysts.



| | $E_a / \text{kJ mol}^{-1}$ |
|--------------------------|----------------------------|
| Without a catalyst | 245 |
| With a gold catalyst | 121 |
| With an iron catalyst | 116 |
| With a platinum catalyst | 136 |

- (i) Use the data in the table to deduce which is the most effective catalyst for this decomposition.

.....

(1)

(ii) Explain how a catalyst increases the rate of a reaction.

.....

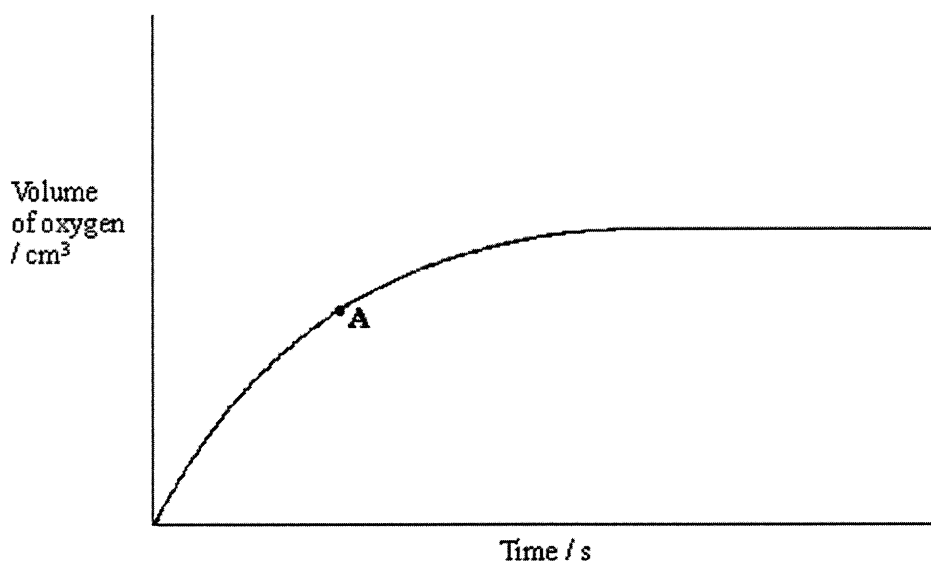
.....

.....

.....

(2)
(Total 7 marks)

2. The curve below shows how the volume of oxygen evolved varies with time when 50 cm³ of a 2.0 mol dm⁻³ solution of hydrogen peroxide, H₂O₂, decomposes at 298 K.



- (a) State how you could use the curve to find the rate of reaction at point A.

.....

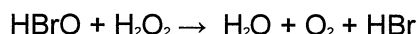
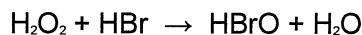
(1)

- (b) Sketch curves, on the above axes, to illustrate how the volume of oxygen evolved would change with time if the experiment was repeated at 298 K using the following.

- (i) 100 cm³ of a 1.0 mol dm⁻³ solution of H₂O₂. Label this curve X.
- (ii) 25 cm³ of a 2.0 mol dm⁻³ solution of H₂O₂ in the presence of a catalyst. Label this curve Y.

(4)

- (c) Hydrogen peroxide decomposes more rapidly in the presence of aqueous hydrogen bromide. The decomposition proceeds as shown by the following equations.



- (i) Write an equation for the overall reaction.

.....

- (ii) Define the term *catalyst*.

.....

.....

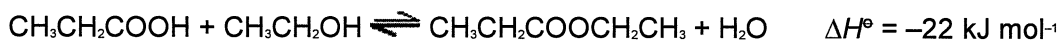
- (iii) Give **two** reasons, other than an increase in the reaction rate, why these equations suggest that hydrogen bromide is behaving as a catalyst.

Reason 1

Reason 2

(5)
(Total 10 marks)

3. A mixture was prepared using 1.00 mol of propanoic acid, 2.00 mol of ethanol and 5.00 mol of water. At a given temperature, the mixture was left to reach equilibrium according to the following equation.



The equilibrium mixture contained 0.54 mol of the ester ethyl propanoate.

- (a) (i) Calculate the amounts, in moles, of propanoic acid, of ethanol and of water in this equilibrium mixture.

Moles of propanoic acid

Moles of ethanol

Moles of water

(3)

- (ii) Write an expression for the equilibrium constant, K_c , for this equilibrium.

.....

.....

(1)

- (iii) Calculate a value for K_c for this equilibrium at this temperature. Explain why this K_c value has no units.

Calculation

.....

.....

Explanation

.....

(3)

- (b) For this equilibrium, predict the effect of an increase in temperature on each of the following.

- (i) the amount, in moles, of ester at equilibrium

.....

(1)

- (ii) the time taken to reach equilibrium

.....

(1)

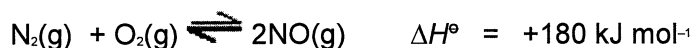
- (iii) the value of K_c

.....

(1)

(Total 10 marks)

4. At high temperatures, nitrogen is oxidised by oxygen to form nitrogen monoxide in a reversible reaction as shown in the equation below.



- (b) State and explain the effect of an increase in pressure, and the effect of an increase in temperature, on the yield of nitrogen monoxide in the above equilibrium.

Effect of an increase in pressure on the yield

Explanation

.....

.....

Effect of an increase in temperature on the yield

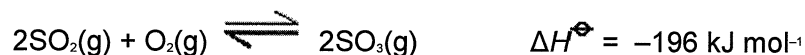
Explanation

.....

.....

(Total 6 marks)

5. Sulphur dioxide and oxygen were mixed in a 2:1 mol ratio and sealed in a flask with a catalyst. The following equilibrium was established at temperature T_1



- (a) When equilibrium was established at a different temperature, T_2 , the value of K_p was found to have increased. State which of T_1 and T_2 is the lower temperature and explain your answer.

Lower temperature.....

Explanation

.....

(3)

- (b) In a further experiment, the amounts of sulphur dioxide and oxygen used, the catalyst and the temperature, T_1 , were all unchanged, but a flask of smaller volume was used.

Deduce the effect of this change on the yield of sulphur trioxide and on the value of K_c .

Effect on yield of SO_3

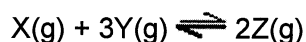
Effect on K_c

.....

(2)

(Total 5 marks)

6. A sealed flask containing gases X and Y in the mole ratio 1:3 was maintained at 600 K until the following equilibrium was established.



When this reaction is carried out at 300 K and a high pressure of 100 MPa, rather than at 600 K and 22.0 MPa, a higher equilibrium yield of gas Z is obtained.

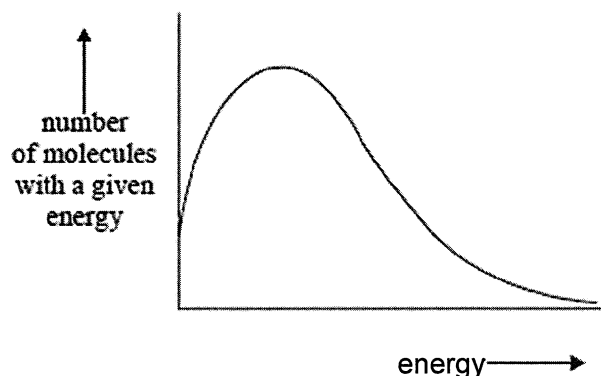
Give two reasons why an industrialist is unlikely to choose these reaction conditions.

Reason 1

Reason 2

(Total 2 marks)

7.



The total area under the distribution curve represents

- A total energy.
- B activation energy.
- C total number of reacting molecules.
- D total number of molecules present.

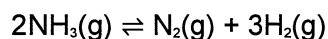
(Total 1 mark)

8. The standard enthalpy of formation, ΔH_f for $\text{O}_3(\text{g})$ is + 142 kJ mol⁻¹. In which one of the following would both the changes shown increase the amount of O_2 gas in an equilibrium mixture containing only $\text{O}_2(\text{g})$ and $\text{O}_3(\text{g})$?

- A increasing the temperature and increasing the pressure
- B increasing the temperature and decreasing the pressure
- C decreasing the temperature and increasing the pressure
- D decreasing the temperature and decreasing the pressure

(Total 1 mark)

9. When one mole of ammonia is heated to a high temperature, 50% dissociates according to the following equilibrium.



What is the total number of moles of gas present in the equilibrium mixture?

- A 1.5
- B 2.0
- C 2.5
- D 3.0

(Total 1 mark)

10. The ester methyl ethanoate is hydrolysed as shown in the following equation.



The equilibrium yield of ethanoic acid could be increased by

- A lowering the temperature.
- B adding a catalyst.
- C adding more water to the reaction mixture.
- D adding more methanol to the reaction mixture.

(Total 1 mark)

11. The ester methyl ethanoate is hydrolysed as shown in the following equation.



A 3 mol sample of methyl ethanoate was mixed with 3 mol of water and left to reach equilibrium at 298 K. The equilibrium yield of ethanoic acid was 2 mol. The value of K_c for this reaction at 298 K is

- A $\frac{2}{3}$
- B $\frac{4}{9}$
- C 2
- D 4

(Total 1 mark)

12. The equilibrium constant, K_c , for a reaction which leads to ozone (O_3) formation is

$$K_c = \frac{[\text{N}_2][\text{O}_3]^2}{[\text{NO}]^2[\text{O}_2]^2}$$

More ozone is formed as the temperature rises. Which one of the following is true at equilibrium?

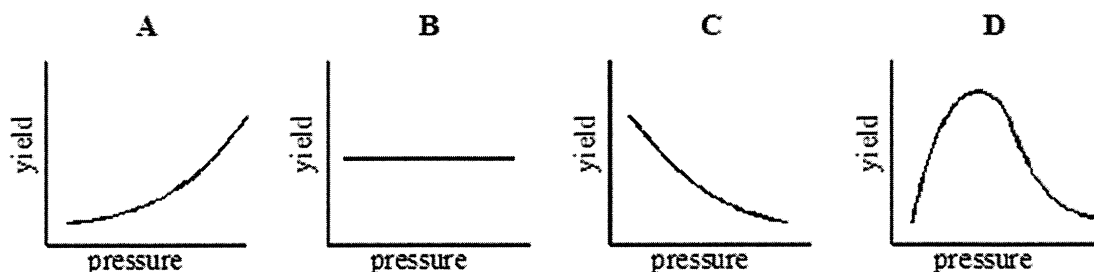
- A When ozone molecules collide with nitrogen they may form nitrogen monoxide.
- B The enthalpy change for the reaction has a negative sign.
- C Less ozone is formed at high pressure.
- D At a fixed temperature, the magnitude of K_c increases as the concentration of NO decreases.

(Total 1 mark)

13. Phosphorus(V) chloride decomposes at high temperatures into phosphorus(III) chloride and chlorine according to the equation.

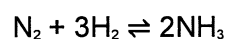


Which one of the graphs best represents the variation with pressure of the yield of chlorine at equilibrium?

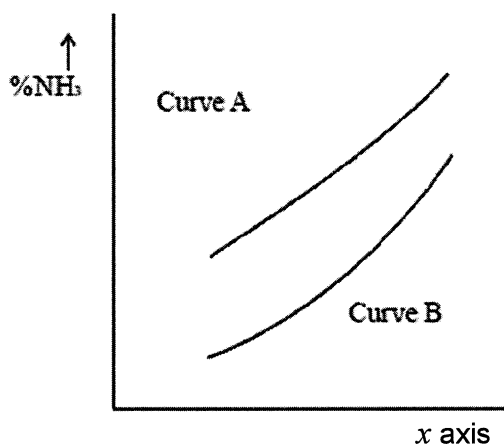


(Total 1 mark)

14. The graph shows the equilibrium percentage of ammonia present during the formation of ammonia by the Haber process:



$$\Delta H = -92 \text{ kJ mol}^{-1}$$

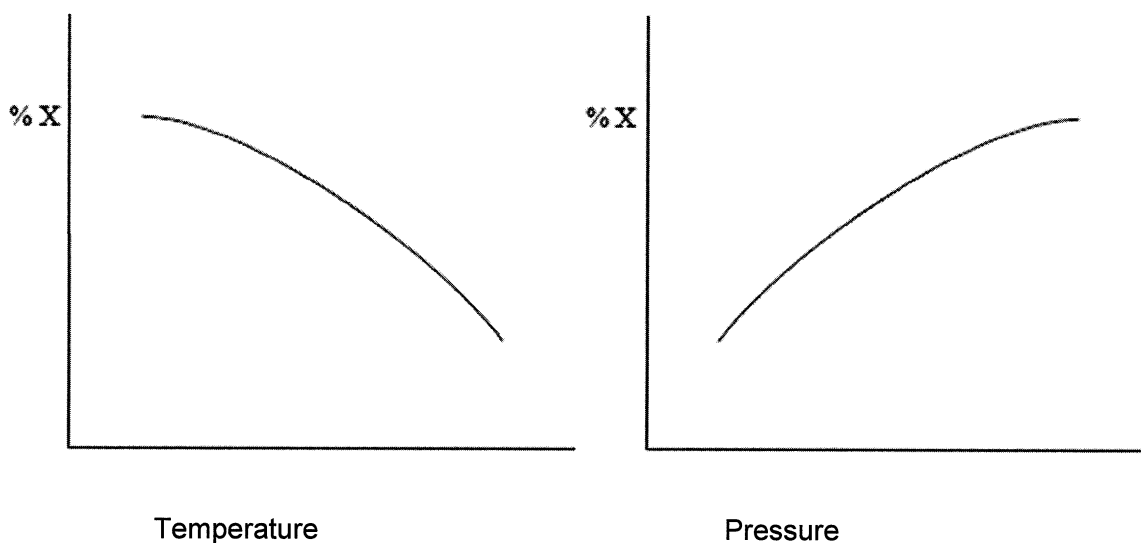


Which one of the following are correct labels for the graph?

| | <i>x axis</i> | <i>Curve A</i> | <i>Curve B</i> |
|---|---------------|------------------|------------------|
| A | temperature | high pressure | low pressure |
| B | temperature | low pressure | high pressure |
| C | pressure | high temperature | low temperature |
| D | pressure | low temperature | high temperature |

(Total 1 mark)

15. A compound X is formed during a gas phase reaction. The graphs below show how the percentage of a compound X present at equilibrium varies with temperature and pressure.

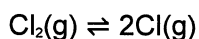


Which one of the following statements concerning the formation of X is correct?

- A The reaction is exothermic and involves a decrease in the number of moles of gas.
- B The reaction is exothermic and involves no change in the number of moles of gas.
- C The reaction is exothermic and involves an increase in the number of moles of gas.
- D The reaction is endothermic and involves a decrease in the number of moles of gas.

(Total 1 mark)

16. A sample of chlorine gas was sealed in a tube, heated and an equilibrium was established.



Which one of the following is **not** true?

- A The concentration of chlorine atoms remains the same when a catalyst is added to the tube.
- B Increase in temperature causes an increase in the concentration of chlorine atoms.
- C Increase in pressure causes an increase in the concentration of chlorine atoms relative to chlorine molecules.
- D Addition of more chlorine gas to the tube causes an increase in the concentration of chlorine atoms.

(Total 1 mark)

Energetics

| Energetics |
|---|
| T 1. Define standard enthalpy of combustion |
| T 2. Define standard enthalpy of formation |
| T 3. Use $q = mc\Delta T$ to calculate the molar enthalpy change for a reaction |
| T 4. Use $q = mc\Delta T$ in related calculations |
| T 5. Use Hess's law to perform calculations, including calculation of enthalpy changes for reactions from enthalpies of combustion or from enthalpies of formation. |
| T 6. Define the term mean bond enthalpy |
| T 7. Use mean bond enthalpies to calculate an approximate value of ΔH for reactions in the gaseous phase |
| T 8. Explain why values from mean bond enthalpy calculations differ from those determined using Hess's law. |

Exam booklet reflection:

WWW

EBI

Checked by teacher

Doddle quiz homework:

Energetics 1

Score:

Energetics 2

Score:

AS LEVEL CHEMISTRY

TOPIC 4 – ENERGETICS TEST

Answer all questions

Max 50 marks

| | | | |
|------|----------|--------|-------------|
| Name | | | |
| Mark |/50 |% | Grade |

1. (a) Explain the meaning of the terms *mean bond enthalpy* and *standard enthalpy of formation*.

Mean bond enthalpy

.....

.....

Standard enthalpy of formation

.....

.....

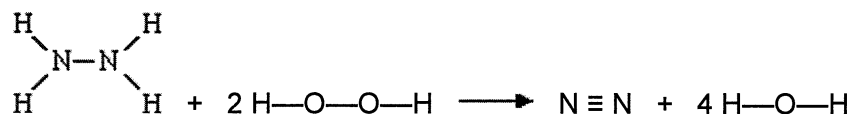
.....

(5)

- (b) Some mean bond enthalpies are given below.

| Bond | N-H | N-N | N≡N | H-O | O-O |
|---|-----|-----|-----|-----|-----|
| Mean bond enthalpy/kJ mol ⁻¹ | 388 | 163 | 944 | 463 | 146 |

Use these data to calculate the enthalpy change for the following gas-phase reaction between hydrazine, N₂H₄, and hydrogen peroxide, H₂O₂



.....

.....

.....

.....

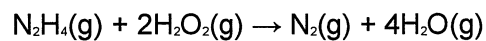
.....

(3)

- (c) Some standard enthalpies of formation are given below.

| | $\text{N}_2\text{H}_4(\text{g})$ | $\text{H}_2\text{O}_2(\text{g})$ | $\text{H}_2\text{O}(\text{g})$ |
|---|----------------------------------|----------------------------------|--------------------------------|
| $\Delta H_f^\circ / \text{kJ mol}^{-1}$ | +75 | −133 | −242 |

These data can be used to calculate the enthalpy change for the reaction in part (b).



- (i) State the value of ΔH_f° for $\text{N}_2(\text{g})$.

.....

- (ii) Use the ΔH_f° values from the table to calculate the enthalpy change for this reaction.

.....

.....

.....

.....

.....

(4)

- (d) Explain why the value obtained in part (b) is different from that obtained in part (c)(ii).

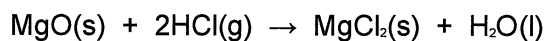
.....

.....

(1)

(Total 13 marks)

2. (a) State Hess's Law and use it, together with the data given in the table below, to calculate the standard enthalpy change for the following reaction.



| | MgO | HCl(g) | MgCl ₂ | H ₂ O |
|---|------|--------|-------------------|------------------|
| $\Delta H_f^\ominus / \text{kJ mol}^{-1}$ | −602 | −92 | −642 | −286 |

(4)

- (b) In an experiment, an excess of solid magnesium oxide was added to 50 cm³ of 3.0 mol dm^{−3} hydrochloric acid. The initial temperature of the solution was 21 °C. After reaction, the temperature had risen to 53 °C. (The specific heat capacity of water is 4.2 J K^{−1} g^{−1})

Use this information to calculate the enthalpy change for the reaction of one mole of magnesium oxide with hydrochloric acid. For your calculation you should assume that all the heat from the reaction is used to raise the temperature of 50 g of water.

(8)
(Total 12 marks)

3. The table below contains some mean bond enthalpy data.

| Bond | H—H | C—C | C=C | N≡N | N—H |
|---|-----|-----|-----|-----|-----|
| Mean bond enthalpy / kJ mol ⁻¹ | 436 | 348 | 612 | 944 | 388 |

- (a) (i) Write an equation for the formation of one mole of ammonia, NH₃, from its elements.

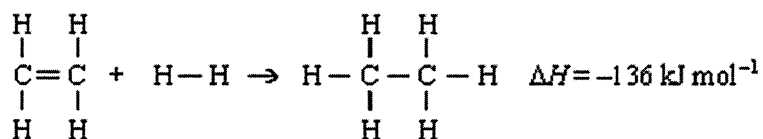
.....

- (ii) Use data from the table above to calculate a value for the enthalpy of formation of ammonia.

.....

(4)

- (b) Use the following equation and data from the table above to calculate a value for the C—H bond enthalpy in ethane.



.....

(3)

(Total 7 marks)

4. (a) Write an equation for the complete combustion of propanone, $\text{C}_3\text{H}_6\text{O}$, to form carbon dioxide and water.

.....

(1)

- (b) In a laboratory experiment, 1.45 g of propanone were burned completely in oxygen. The heat from this combustion was used to raise the temperature of 100 g of water from 293.1 K to 351.2 K.

- (i) Calculate the number of moles of propanone in the 1.45 g.

.....

.....

- (ii) Calculate the heat energy required to raise the temperature of 100 g of water from 293.1 K to 351.2 K.
(The specific heat capacity of water is $4.18 \text{ J K}^{-1} \text{ g}^{-1}$)

.....

.....

.....

.....

- (iii) Hence, calculate a value, in kJ mol^{-1} , for the enthalpy of combustion of propanone.

.....

.....

(5)

- (c) In a similar experiment, the enthalpy of combustion of butanone, $\text{C}_4\text{H}_8\text{O}$, was found to be $-1290 \text{ kJ mol}^{-1}$. A data book value for the same reaction is $\Delta H_c^\ominus = -2430 \text{ kJ mol}^{-1}$.

- (i) Suggest one reason why the experimental value is very different from the data book value.

.....

- (ii) This data book value of ΔH_c^\ominus for butanone ($-2430 \text{ kJ mol}^{-1}$) refers to the formation of carbon dioxide gas and water in the gaseous state. How would this value differ if it referred to the formation of water in the liquid state? Explain your answer.

Difference

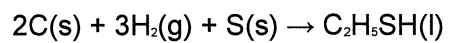
Explanation

.....

(3)

- (d) Calculate a value for the standard enthalpy of formation for liquid ethanethiol, $\text{C}_2\text{H}_5\text{SH}$. Use the equation given below and enthalpy of combustion data from the following table.

| Substance | $\text{C}_2\text{H}_5\text{SH}(\text{l})$ | $\text{C}(\text{s})$ | $\text{H}_2(\text{g})$ | $\text{S}(\text{s})$ |
|---|---|----------------------|------------------------|----------------------|
| $\Delta H_c^\ominus / \text{kJ mol}^{-1}$ | -1170 | -394 | -286 | -297 |

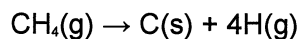


(3)
(Total 12 marks)

5. Given the following data



which one of the following is the enthalpy change, in kJ mol^{-1} , of the reaction below?



- A -947
- B +511
- C +797
- D +947

(Total 1 mark)

6. Use the information below to answer this question.



The value in kJ mol^{-1} of the enthalpy of thermal dissociation when butane forms propane, hydrogen and carbon is

- A -26.3
- B -17.5
- C +17.5
- D +21.2

(Total 1 mark)

7. When ethanamide (CH_3CONH_2) burns in oxygen the carbon is converted into carbon dioxide, the hydrogen is converted into water and the nitrogen forms nitrogen gas.

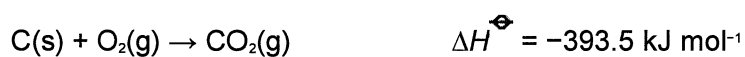
| Substance | ethanamide | carbon dioxide | water |
|---|------------|----------------|-------|
| Enthalpy of formation (ΔH_f^\ominus) / kJ mol^{-1} | -320 | -394 | -286 |

Using the data above, which one of the following is a correct value for the enthalpy of combustion of ethanamide?

- A -1823 kJ mol^{-1}
 B -1183 kJ mol^{-1}
 C -1000 kJ mol^{-1}
 D -360 kJ mol^{-1}

(Total 1 mark)

8. Use the information below to answer this question.



The value in kJ mol^{-1} for the enthalpy of combustion of propane is

- A -211.7
 B -419.7
 C -2220
 C -2878

(Total 1 mark)

9. The table below shows data for the four hydrocarbons ethyne, propyne, propene and propane. ΔH_c^\ominus is the standard enthalpy of combustion of these hydrocarbons.

| Compound | Name | M_r | $-\Delta H_c^\ominus / \text{kJ mol}^{-1}$ |
|-------------------------------------|---------|-------|--|
| $\text{HC}\equiv\text{CH}$ | ethyne | 26 | 1300 |
| $\text{HC}\equiv\text{CCH}_3$ | propyne | 40 | 1940 |
| $\text{H}_2\text{C}=\text{CHCH}_3$ | propene | 42 | 2060 |
| $\text{CH}_3\text{CH}_2\text{CH}_3$ | propane | 44 | 2220 |

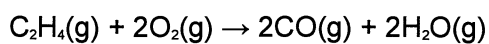
The complete combustion of 2.0 g of one of the above hydrocarbons releases exactly 100 kJ of heat energy.

This hydrocarbon is

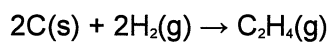
- A ethyne
- B propyne
- C propene
- D propane

(Total 1 mark)

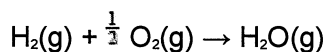
10. Consider the reactions



$$\Delta H^\ominus = -758 \text{ kJ mol}^{-1}$$



$$\Delta H^\ominus = +52 \text{ kJ mol}^{-1}$$



$$\Delta H^\ominus = -242 \text{ kJ mol}^{-1}$$

The enthalpy of formation of carbon monoxide is

- A -111 kJ mol^{-1}
- B -163 kJ mol^{-1}
- C -222 kJ mol^{-1}
- D -464 kJ mol^{-1}

(Total 1 mark)