

Directorate: Curriculum FET

# TELEMATICS

# **GRADE 12**

# PHYSICAL SCIENCES CAPS

ENGLISH

# QUESTIONS, ANSWERS AND STUDY TIPS

# INVERSE PROPORTION F<sub>net</sub> MOTION OF CONNECTED BODIES PHYSICAL PROPERTY RELATIONSHIPS

2018

#### LESSON 1: INVERSE PROPORTION AND Fnet

- 1.1 The magnitude of the gravitational force exerted by a body **A** on another body **B** is *F*. When the distance between the centres of the two bodies is doubled, the magnitude of the gravitational force, in terms of *F*, will now be ...
  - $\begin{array}{c} A & \frac{1}{4}F \\ B & \frac{1}{2}F \\ C & 2F \\ D & 4F \end{array}$

# (2)

#### Answer: 1.1 A Method 1:

**Study Tips:** Technique to answer questions based on inverse proportional relationships: Express new force (call it  $F_N$ ) in terms of the original force **F** (Call it  $F_O$ ).

Procedure:

STEP 1: Identify the variables involved: F and d

STEP 2: Write down the formula involved:  $F = G \frac{m_1 m_2}{d^2}$ 

STEP 3: Write down the equation for the original force  $F_0$ :  $F_0 = G \frac{m_1 m_2}{d^2}$ 

STEP 4: Write down the equation for the new force  $F_N$ :  $F_N = G \frac{m_1 m_2}{4d^2}$ 

STEP 5: Express  $F_N$  in terms of  $F_0$ :  $F_N = G \frac{m_1 m_2}{4d^2} = \frac{1}{4}G \frac{m_1 m_2}{4d^2} = \frac{1}{4}G \frac{m_1 m_2}{4d^2} = \frac{1}{4}F_0$ 

STEP 5: Because  $F_0$  is F, the new gravitational force is  $\frac{1}{4}F$ 

#### Method 2:

**Study Tips:** Another technique to answer questions based on inverse proportional relationships: Write down the proportion as an equation. Use it to deduce the answer. **NOTES:** Two variables A and B are inversely proportional if AxB = k, where k is a constant. Use this fact to obtain the answer.

Procedure:

STEP 1: Identify the variables involved: F and d

STEP 2: Write the proportion involved as an equation:  $Fxd^2 = k$  (Keep G, m<sub>1</sub> and m<sub>2</sub> constant) STEP 3: If the distance is doubled,  $Fxd^2$  becomes  $Fx(2d)^2 = Fx4d^2 = 4k$  ... (1)

STEP 4: To obtain k again on the RHS of equation (1), divide both sides by 4:  $\frac{F}{4}x4d^2 = \frac{4k}{4}$ 

STEP 5: Simplify:  $\frac{1}{4}$  Fx4d<sup>2</sup> = k, i.e. the new value of F in STEP 2 is  $\frac{1}{4}$  F, which is the answer.

STEP 6: Compare  $F_N$  in STEP 5 with  $F_O$  in STEP 3:

#### Activity 1.1

- What is the value of G on the moon compared to G on earth? Answer (Greater than, Less than or Equal to). Give a reason for your answer.
- 2. The magnitude of the gravitational force exerted on the bodies **A** and **B** in question 1.1 is **F**.
- 2.1 Determine the new force, in terms of **F**, the bodies exert on each other if the distance between them is halved.
- 2.2 Another body is situated due east of **B**. The diagram below illustrates the situation.



If A exerts a gravitational force F on B, calculate the net gravitational force, in terms of F, that A and C exert on B respectively. Assume that A, B and C have identical masses.

- 2.3 The techniques used to answer question 1.1 and 2.2 can be applied in the same way in Coulomb's Law and Electric fields.
- 2.3.1 The magnitude of the electrostatic force exerted by a charge **A** on another charge **B** is *F*. When the distance between the centres of the two charges is doubled, the magnitude of the gravitational force, in terms of *F*, will now be ...
  - $A \qquad \frac{1}{4} \boldsymbol{F}$
  - $B = \frac{1}{2} F$
  - C 2**F**
  - D 4**F**

2.3.2 Two charges of + 2 nC and - 2 nC are located on a straight line. **S** and **T** are two points that lie on the same straight line as shown in the diagram below.

+ 2 nC S - 2 nC T

Which ONE of the following correctly represents the directions of the RESULTANT electric fields at  $\mathbf{S}$  and at  $\mathbf{T}$  respectively?

	DIRECTION OF THE RESULTANT ELECTRIC FIELD AT POINT S	DIRECTION OF THE RESULTANT ELECTRIC FIELD AT POINT T
А	Right	Left
В	Left	Left
С	Right	Right
D	Left	Right

(2)

(2)

(2)

2.3.3 Three small identical metal spheres **R**, **T** and **S** are situated on a straight line. **R** and **S** Carry charges of +2  $\mu$ C respectively whilst **T** carries a charge of + 1  $\mu$ C. The diagram below illustrates the situation.



- (a) Draw a free-body diagram showing the electrostatic forces experienced by sphere **T** due to spheres **R** and **S** respectively.
- (b) Calculate the net electrostatic force experienced by **T** due to **R** and **S** respectively. (6)
- (c) Define the *electric field at a point*.
- (d) Calculate the magnitude of the net electric field at the location of **T** due to **R** and **S** respectively. (Treat the spheres as if they were point charges.) (3)

(2)

LESSON 2: MOTION OF CONNECTED BODIES. PHYSICAL PROPERTY RELATIONSHIPS

- 2.1 Which ONE of the following physical quantities is a measure of the inertia of a body?
  - A Mass
  - B Energy
  - C Velocity
  - D Acceleration

#### Answer: 1.1 A

**Study Tips:** This question is testing content knowledge. **Definition of inertia:** The tendency of a body to resist a change in state of rest or motion.

What gives an object inertia? Answer: It's mass.

2.2 Consider the problem below:

Two blocks of masses 20 kg and 5 kg respectively are connected by a light string, **P**. A second light string, **Q**, attached to the 5 kg block, runs over a light frictionless pulley. A constant horizontal force of 250 N pulls the second string as shown in the diagram below. The magnitudes of the tensions in **P** and **Q** are T<sub>1</sub> and T<sub>2</sub> respectively. Ignore the effects of air friction.



2.2.1 State Newton's Second Law of Motion in words.

- 2.2.2 Draw a labelled free-body diagram indicating ALL the forces acting on the **5 kg block**.
- 2.2.3 Calculate the magnitude of the tension  $T_1$  in string **P**.

(3) (6)

(1)

2.2.4 When the 250 N force is replaced by a sharp pull on the string, one of the two strings break.

Which ONE of the two strings, **P** or **Q**, will break?

#### Answers:

2.2.1: When a resultant / net force acts on an object, the object will accelerate in the direction of the force. This acceleration is directly proportional to the force and inversely proportional to the mass of the object.

**Study Tips:** ALL DEFINITIONS, PRINCIPLES and LAWS are provided in the EXAMINATION GUIDELINES AND ARE EXAMINABLE. YOU MUST MEMORISE THEM FOR YOUR FINAL EXAMINATION.

2.2.2	<ul> <li>Study Tips: Free body diagrams</li> <li>The block is shown as a dot</li> <li>Vectors are shown as arrows. The head shows direction. The length the approximate size of the vector. The tails all touch the dot</li> <li>T<sub>1</sub> acts downwards and T<sub>2</sub> acts upwards</li> <li>F<sub>g</sub> is the symbol for gravitational force.</li> </ul>	$T_{1}$ $T_{2}$ $F_{g}$
	<ul> <li>Instead of F<sub>g</sub>, w that stands for weight, can be used.</li> <li>Note: Marks are lost for missing arrow heads, tails not touching the dot.</li> </ul>	<b>Study Tips:</b> Marks can also be lost if relative sizes of arrows are incorrect.

# 2.2.3

# Answer: T<sub>1</sub> = 200 N

**Study Tips:** Draw separate free body diagrams for each block. Use each diagram to obtain the equation  $F_{net}$  = ma. Solve the two equations simultaneously by elimination. NOTE: **F**<sub>net</sub> **IS A SUM OF VECTORS.** 

**SIGN CONVENTION**: Take vectors pointing upwards as POSITIVE. Procedure

# Method 1:

STEP1: Refer to the free body diagram for the 5 kg block in 2.2.2. The free body diagram for the 20 kg block is shown below.

STEP 2: For the 5 kg block:  $F_{net} = ma = 5a$  $T_2 + (-T_1) + (-F_g) = 5a \dots (1)$ For the 20 kg block:  $\therefore T_1 + (-F_q) = 20a \dots (2)$ Note that  $T_2 = 250$  N (Reason: Tension on either side of the pulley has same magnitude. We can obtain the value for  $F_{g}$  for each block using  $F_{g}$ = mg. Remove the brackets: Equation (1) becomes:  $250 - T_1 - (5)(9,8) = 5a$  ... (3) Equation (2) becomes:  $T_1 - (20)(9,8) = 20a \dots$ (4) Eliminate  $T_1$ : (3) + (4):  $250 - 49 - 196 = 25a \dots (5)$ From (5):  $a = \frac{5}{25} = 0.2 \text{ m.s}^{-2}$ Substitute a = 0,2 into (4) and then solve for  $T_1$ : (4) becomes:  $T_1 - (20)(9,8) = 20(0,2)$  $\therefore$  T<sub>1</sub> = (20)(9,8) + 20(0,2) = 196 + 4 = 200 N

Method 2: At equation (3) and (4), eliminate a:

 $4 \ge (3)$ :
  $1000 - 4T_1 - 196 = 20a \dots (5')$  

 (5') - (4):
  $1000 - 5T_1 = 0$ 
 $\therefore T_1 = 200 \ N$ 

# 2.2.4

Answer: Q

**Study Tips:** If the string is pulled the tension in  $\mathbf{Q}$  (due to the weight of the two blocks) is larger than the tension in  $\mathbf{P}$  (due to the 20 kg block only). Therefore  $\mathbf{Q}$  will stretch and reach breaking point faster than  $\mathbf{P}$ . Further research is needed on inertia to answer other questions like this e.g. What will happen if  $\mathbf{P}$  is given a sudden jerk?

# Organic Chemistry

2.3.1Give a reason why alkanes are saturated hydrocarbons.(1)Answer: Alkanes have single bonds between C- atoms.

Study Tips: The emphasis in the question is on "saturated" and not hydrocarbons.

- 2.3.2 Write down the structural formula of:
  - (a) The functional group of alcohols

(1)

# Answer: $- \stackrel{|}{C} - O - H$

**Study Tips:** A table providing the structural formulae of functional groups is provided on page 16 of the Examination Guidelines. You must be able to draw all these structural formulae in future Final examinations.

(b) A tertiary alcohol that is a structural isomer of butan-1-ol (2)  
H  
H - C - H  
H - H  
I I  
Answer: 
$$H - C - C - C - H$$
  
I I  
H - C - H  
H - C - H  
H - C - H  
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H - H  
H - H  
H - C - H

# Study Tips:

- A tertiary alcohol has an OH group attached to a C-atom that is in turn attached to 3 other C-atoms.
- An isomer of butan-1-ol must have its molecular formula viz: C<sub>4</sub>H<sub>10</sub>O. Check to see if this is true.

Learners investigate factors that influence the boiling points of alkanes and alcohols.

- 2.4 In one of the investigations they determine the boiling points of the first three alkanes.
  - 2.4.1 Write down an investigative question for this investigation.

# Answer: What is the relationship between chain length and boiling point?

# Study Tips: Information on variables and the investigative question.

- In this experiment the independent variable is **chain length**. It is defined as the variable that we change in the experiment.
- The dependent variable is **boiling point**. It is defined as the variable that we are measuring in the experiment.
- An investigative question is a question on the relationship between the independent (**chain length**) and the dependent (**boiling point**) variables.

- In general, an investigative question should be stated as follows: WHAT IS THE RELATIONSHIP BETWEEN THE <u>INDEPENDENT</u> VARIABLE AND THE <u>DEPENDENT</u> VARIABLE?
- It has a question mark at the end.

**Another Study Tip:** Investigative questions are asked on STRUCTURE AND PHYSICAL PROPERTY RELATIONSHIPS, on page 17 of the Examination Guidelines. The following are the physical property relationships that are examinable:

Table 1: Physical property relationships

Boiling point	Strength of IMF	Type of functional group	Chain length	Branched chains
Melting point	Strength of IMF	Type of functional group	Chain length	Branched chains
Vapour pressure	Strength of IMF	Type of functional group	Chain length	Branched chains

IMF = Intermolecular forces

Example to understand Table 1:

Consider the top row in the table. There are 4 physical property relationships that can be examined here viz.

The relationship between:

- Boiling point and Strength of IMF
- Boiling point and Type of functional group
- Boiling point and Chain length (that was examined in 2014)
- Boiling point and Branched Chains

Similarly, the second and third rows from the top of the table give 4 physical property relationships respectively.

Therefore, there 3x4 = 12 relationships from which investigative questions are asked.

WARNING: Do not use relationships not in the table to answer questions on investigative questions. At least one mark will be lost.

2.4.2 Fully explain why the boiling point increases from methane to propane.

(3)

Answer:

- There is increase in chain length
- There is increase in strength of the intermolecular forces
- More energy is required to break the intermolecular forces

**Study Tips:** The question provides the dependent variable viz. boiling point. Now do the following to express the answer:

(3)

- First identify the independent variable viz. <u>chain length</u> (Use Table 1) and state how changing it makes boiling point increase i.e. <u>increase in chain length</u>
- State how <u>increasing chain length</u> affects the strength of intermolecular forces i.e. state: <u>intermolecular forces increase in strength</u>
- State how this affects the energy needed to <u>break the intermolecular</u> forces i.e. more energy is needed to break the intermolecular forces

NOTES: When substances boil they are separated into individual particles, in this case alkane molecules. Energy is needed to break the intermolecular forces that hold the alkane molecules together.

2.5 The learners find that the boiling point of propan-1-ol is higher than that of propane.

Explain this observation by referring to the TYPE of INTERMOLECULAR FORCES present in each of these compounds.

#### Answer:

- In propan-1-ol there are H-bonds and London- or Dispersion forces
- In propane there are only London- or Dispersion forces
- H-bonds are much stronger than London or Dispersion forces

#### Study Tips:

- First state the intermolecular forces that are found in propan-1-ol and propane
- Then compare the strengths of these intermolecular forces

#### LESSON 3: REACTION RATE

3.1 Consider the reaction below:

 $Cu(s) + 2Ag^{+}(aq) \longrightarrow Cu^{2+}(aq) + 2Ag(s)$ 

Which ONE of the following about the average reaction rate for this reaction is incorrect?

A Reaction Rate<sub>Av</sub> =  $\frac{\Delta \text{ mass Cu}}{\Delta t}$ 

B Reaction Rate<sub>Av</sub> = 
$$\frac{\Delta \text{ mass Ag}}{\Delta t}$$

C Reaction Rate<sub>Av</sub> = 
$$\frac{\Delta[Cu^{2}+]}{\Delta t}$$

D 
$$(\frac{\Delta[Ag^+]}{\Delta t}) = \frac{\Delta[Cu^2^+]}{\Delta t}$$

#### Answer: 3.1 A

Study Tips: Study the equation. Note the following:

- LHS: Both the mass of Cu(s) and the [Ag<sup>+</sup>(aq)] decrease. This means: ∆ mass Cu = (mass Cu<sub>f</sub> – mass Cu<sub>i</sub>) < 0 (i.e. it is negative). Similarly, ∆[Ag<sup>+</sup>(aq)] is negative.
- RHS: Both [Cu<sup>2+</sup>] and the mass of Ag increase. This means:
   Δ [Cu<sup>2+</sup>] = ([Cu<sup>2+</sup>]<sub>f</sub> [Cu<sup>2+</sup>]<sub>i</sub>) > 0 (i.e. it is positive). Similarly, Δ mass Ag is positive.
- Hence, if you determine the reaction rate on the LHS your answer is negative but on the RHS it is positive.
- This problem was eliminated by an international agreement that ALL REACTION RATES ARE POSITIVE (Refer to any university textbook or to IUPAC's Golden Book to verify this.)

#### 3.2 Define the term *reaction rate* in words.

**Answer:** The change in the concentration of a reactant or product per unit time. **Study Tips:** This question is testing recall. This definition can be found on page 19 of the CAPS EG (Examination Guidelines). ALL STATEMENTS OF DEFINITIONS, LAWS AND PRINCIPLES ARE PROVIDED IN THE EG. YOU MUST BE ABLE TO REPRODUCE THEM IN THE FINAL EXAMINATION.

#### Activity 1

- 1. Use the definition of reaction rate to:
- 1.1 Write down a formula that can be used to calculate reaction rate.
- 1.2 Deduce the unit of measurement for reaction rate.

Learners use the reaction between IMPURE POWDERED calcium carbonate and excess

(2)

(2)

hydrochloric acid to investigate reaction rate. The balanced equation for the reaction is:

 $CaCO_3(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + H_2O(\ell) + CO_2(g)$ 

They perform four experiments under different conditions of concentration, mass and temperature as shown in the table below. They use identical apparatus in the four experiments and measure the volume of gas released in each experiment.

	EXPERIMENT			
	1	2	3	4
Concentration of acid (mol·dm <sup>-3</sup> )	1	0,5	1	1
Mass of impure calcium carbonate (g)	15	15	15	25
Initial temperature of acid (°C)	30	30	40	40

3.3 The results of experiments **1** and **3** are compared in the investigation.

Write down the:

3.3.1 Independent variable

**Answer:** Temperature

**Study Tips**: The independent variable is the one you CHANGE in the experiment. To find the answer, look at experiment 1 and 3 and find out what the CHANGE is. You will

see that only the temperature is CHANGED. The answer is  $\therefore$  Temperature

3.3.2 Dependent variable

Answer: Reaction rate OR Volume of gas released

Study Tips: The dependent variable is the one you are MEASURING in the

#### experiment.

You have to read the text in the question to find the answer. The answer is given in the

1<sup>st</sup> sentence, immediately below Activity 1.1 viz. reaction rate OR in the 3<sup>rd</sup> sentence viz. volume of gas released.

3.4 Use the collision theory to explain why the reaction rate in experiment **4** will be higher than that in experiment **3**.

**Answer:** In experiment **4** there is a larger mass (of  $CaCO_3$ ). There are thus more  $CaCO_3$  particles that collide with the same kinetic energy and correct orientation per

unit

time in experiment **4** than in experiment **3**.

**Study Tips:** The Maxwell-Boltzmann distribution shows you better, what is happening:

(1)

(3)

(1)



The learners obtain graphs A, B, C and D below from their results.



Time (s)

3.5 Which ONE of the graphs (**A**, **B**, **C** or **D**) represents experiment 1? Fully explain the answer by comparing experiment 1 with experiments 2, 3 and 4.

#### Answer: C

Study Tips: Compare the reaction rate of experiment 1 with 2, 1 with 3, 1 with 4 and 3 with 4, using the information given in the table. Then match them with the reaction rate given by graphs A to D respectively.

Comparison	Observation	Match observation with graph
1 with 2	Reaction rate exp. 1 > Reaction rate exp. 2	Reaction 1 is graph C
1 with 3	Reaction rate exp.3 > Reaction rate exp. 1	Reaction 2 is graph D
1 with 4	Reaction rate exp.4 > Reaction rate exp. 1	Reaction <b>3</b> is graph <b>B</b>
3 with 4	Reaction rate exp.4 > Reaction rate exp. 3	Reaction 4 is graph A

3.6 When the reaction in experiment **4** reaches completion, the volume of gas formed is  $4,5 \text{ dm}^3$ . Assume that the molar gas volume at 40 °C is equal to 25,7 dm<sup>3</sup>.

Calculate the mass of the impurities present in the calcium carbonate.

(5)

(6)

**Study Tips:** Note: The "gas" in the question is  $CO_2$  (Refer to the given equation). Write down what you are given:

Mass  $(CaCO_3)$  at start = m = 25 g Molar gas volume = V<sub>m</sub> = 25,7 dm<sup>3</sup> Answer

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#### Method:

STEP 1: Find the moles of  $CO_2(g)$  that were formed in the reaction.

$$n(CO_2) = \frac{V}{V_m} = \frac{4.5}{25.7} = 0.18 \text{ mol}$$

#### STEP 2: Find the moles of $CaCO_3(s)$ that reacted to form the moles of $CO_2$ in the reaction. From the balanced equation:

$$\begin{aligned} & \text{CaCO}_3(s) + 2\text{HCl}(aq) \rightarrow \text{CaCl}_2(aq) + \text{H}_2\text{O}(\ell) + \text{CO}_2(g) \\ & \text{n}(\text{CaCO}_3) = \text{n}(\text{CO}_2) = 0,18 \text{ mol (from STEP 1)} \end{aligned}$$

STEP3: Convert the moles of CaCO<sub>3</sub>(s) in STEP 2 to mass

$$n(CaCO_3) = \frac{m}{M}$$
 i.e.  $0,18 = \frac{m}{100}$  i.e.  $m = (0,18)(100) = 18$  g

STEP 4: Subtract the mass in STEP 3 from 25 g to obtain the answer.

 $\therefore$  mass of impurities in the CaCO<sub>3</sub> = 25 - 18 = 7,00 g

# Activity 2

- 1. Draw the Maxwell-Boltzmann distribution to show how concentration increases reaction rate.
- 2. Calculate the mass of HC $\ell$  needed to produce 0,18 mol of CO<sub>2</sub>(g).

# LESSON 4: ACIDS AND BASES

- 4.1 Nitric acid  $(HNO_3)$ , an important acid used in industry, is a strong acid.
  - 4.1.1 Give a reason why nitric acid is classified as a strong acid. (1)

**Answer:** It ionizes completely (100%) in water. Refer to EG page 20. **Study Tips:** The following acids are also strong acids that ionize completely (100%) in water: HC $\ell$ , HBr, H<sub>2</sub>SO<sub>4</sub> (1<sup>st</sup> ionization)

4.1.2 Write down the NAME or FORMULA of the conjugate base of nitric acid.

**Answer:** NO<sub>3</sub><sup>-</sup> or Nitrate ion **Study Tips:** 

 A conjugate base is obtained from an acid by the REMOVAL of ONE PROTON (H<sup>+</sup>) from the acid. Example: NO<sub>3</sub><sup>-</sup> is the conjugate base of

 $HNO_3$ 

 A conjugate acid is obtained from a base by the ADDITION OF ONE PROTON (H<sup>+</sup>). Example: HNO<sub>3</sub> is the conjugate acid of NO<sub>3</sub><sup>-</sup> (1)

(3)

4.1.3 Calculate the pH of a  $0,3 \text{ mol} \cdot \text{dm}^{-3}$  nitric acid solution.

**Answer:**  $pH = -log[H_3O^+] = -log(0,3) = -(-0,52) = 0,52$ **Study Tips:** 

- You must be able to use a scientific calculator.
- You must know all the log laws from mathematics and apply them to chemistry.
- 4.2 A laboratory technician wants to determine the percentage purity of magnesium oxide. He dissolves a 4,5 g sample of the magnesium oxide in 100 cm<sup>3</sup> hydrochloric acid of concentration 2 mol·dm<sup>-3</sup>.
  - 6.2.1 Calculate the number of moles of hydrochloric acid added to the magnesium oxide.

(3)

**Answer:** n = cV = (2)(0,1) = 0,2 mol **Study Tips:** Method to find  $n(HC\ell)$ : STEP 1: Write down the given:  $V(HC\ell) = 100 \text{ cm}^3$  [HC\ell] = 0,2 mol.dm<sup>-3</sup> STEP 2: Write down what you have to calculate viz:  $n(HC\ell)$ STEP 3: Write down an equation that contains the variables in STEP 1 and 2

viz.

 $c = \frac{n}{V}$ 

STEP 4: Convert 100 cm<sup>3</sup> to dm<sup>3</sup>: Divide 100 cm<sup>3</sup> by 1000 to obtain 0,1 dm<sup>3</sup> NOTES: Procedure: If 10 cm = 1 dm, then  $(10 \text{ cm})^3 = (1 \text{ dm})^3$  i.e.

 $1000 \text{ cm}^3 = 1 \text{ dm}^3$ 

STEP 5: Now calculate  $n(HC\ell)$ :  $n(HC\ell) = cV$ , etc.

He then uses the apparatus below to titrate the EXCESS hydrochloric acid in the above solution against a sodium hydroxide solution.



4.2.2 Write down the name of apparatus **Q** in the above diagram.

(1)

# Answer: Burette

**Study Tips:** PRACTICAL WORK IS EXAMINABLE. You must know the experiments done for your SBA mark and those that are demonstrated by your teacher. Know safety precautions too. Note that practical work is examinable. Refer to section 2.6 of the EG for more information.

4.2.3 The following indicators are available for the titration:

INDICATOR	pH RANGE
Α	3,1 – 4,4
В	6,0-7,6
С	8,3 – 10,0

Which ONE of the above indicators (A, B or C) is most suitable to indicate the exact endpoint in this titration? Give a reason for the answer.

(3)

# Answer: B

**Study Tips:** What is hydrolysis? It is the reaction of a salt with water to form a solution that is acidic or basic. We use our knowledge of hydrolysis and pH to choose an indicator for a titration.

- If the substances used in the titration are HCl, a strong acid, and NaOH, a strong base, the pH of the solution that forms is 7.
- If the titration is between a <u>weak acid</u> such as CH<sub>3</sub>COOH and a <u>strong base</u> such as NaOH, the salt formed, CH<sub>3</sub>COONa, undergoes <u>cationic hydrolysis</u>, as shown below:

 $CH_3COO^- + H^+ + OH^- \rightarrow CH_3COOH + OH^-$ . The OH<sup>-</sup> ion makes the solution basic. Indicator **C** should be used for this titration.

 If the titration is between a <u>strong acid</u> such as HCl and a <u>weak base</u> such as NH<sub>3</sub>, the salt formed, NH<sub>4</sub>Cl, undergoes <u>anionic hydrolysis</u>, as shown below:

 $NH_4^+ + H^+ + OH^- \rightarrow NH_4OH + H^+$ The H<sup>+</sup> ion formed makes the solution acidic. Indicator **A** should be used for this titration

4.2.4 During the titration, the technician uses distilled water to wash any sodium hydroxide spilled against the sides of the Erlenmeyer flask into the solution.

Give a reason why the addition of distilled water to the Erlenmeyer (1)

(.

flask will not influence the results.

**Answer:**  $n(OH^{-})$  remains constant. **Study Tips:** The endpoint is dependent only on the  $n(H^{+})$  and the  $n(OH^{-})$  present but not on the water added.

4.2.5 At the endpoint of the titration he finds that 21 cm<sup>3</sup> of a 0,2 mol dm<sup>-3</sup> sodium hydroxide solution has neutralized the EXCESS hydrochloric acid.
Calculate the number of moles of hydrochloric acid in excess. (3) Study Tips: Follow the STEPS in 6.2.1 to obtain the answer. The balanced chemical equation for the reaction between NaOH and

HCl is:

NaOH + HC $\ell \rightarrow$  NaC $\ell$  + H<sub>2</sub>O

Answer

$$n(NaOH) = cV = (0,2)(0,021) = 0,0042 = n(HC\ell)$$

4.2.6 The balanced equation for the reaction between hydrochloric acid and magnesium oxide is:

 $MgO(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + H_2O(\ell)$ 

Calculate the percentage purity of the magnesium oxide. Assume that only the magnesium oxide in the 4,5 g sample reacted with the acid.

**Study Tips:** The problem solving process to obtain the answer is shown below:

STEP 1: Calculate the n(HC $\ell$ ) that reacted with the MgO. n(HC $\ell$ )<sub>reacted</sub> = 0,2 - 0,0042= 0,1958 mol

STEP 2: From the balanced equation in 6.2.6, obtain n(MgO) that reacted with the  $n(HC\ell)$ .

n(MgO) : n(HCℓ) = 1:2 ∴n(MgO) = ½ (n(HCℓ) = ½ (0,1958) = 0,0979 mol

STEP 3: From the n(MgO) calculated in STEP 2, calculate the

mass of

MgO that reacted with the HC $\ell$ . Mass(MgO) = nM = (0,0979)(40) = 3,916 g

STEP 4: Calculate the %age purity of the MgO.

% age purity of the MgO =  $\frac{3,916}{4,5}$  x 100% = 87,02%

Activity 4.1

3,6 g of commercial washing soda (Na<sub>2</sub>CO<sub>3</sub>. 10H<sub>2</sub>O) are dissolved in a 250 cm<sup>3</sup>

(5)

measuring flask, which is then filled to the mark. In a titration, 25 cm<sup>3</sup> of this commercial washing powder solution was neutralised by 23,5 cm<sup>3</sup> of a HC $\ell$  solution of concentration 0,11 mol.dm<sup>-3</sup>. The balanced chemical equation for the reaction is:

 $Na_2CO_3$  + 2HCl  $\rightarrow$  2NaCl + CO<sub>2</sub> + H<sub>2</sub>O

- 4.1.1 Choose a suitable indicator for this titration, using the table in question 6.2.3.
- 4.1.2 Give a reason why the water of hydration is omitted from the balanced equation.
- 4.1.3 Calculate the n(HCl) that reacted with the Na<sub>2</sub>CO<sub>3</sub> in the titration.
- 4.1.4 Calculate the  $n(Na_2CO_3)$  in the 250 cm<sup>3</sup> measuring flask.
- 4.1.5 Calculate the percent (%) of  $Na_2CO_3$  in the commercial washing soda ( $Na_2CO_3$ .  $10H_2O$ )

# LESSON 5: ELECTROLYTIC CELLS

5.1 An electrochemical cell is used to electroplate an iron spoon with nickel.

Which ONE of the following half-reactions takes place at the positive electrode of this cell?

- A  $Fe^{2+}(aq) + 2e^{-} \rightarrow Fe(s)$
- B Fe(s)  $\rightarrow$  Fe<sup>2+</sup>(aq) + 2e<sup>-</sup>
- C Ni<sup>2+</sup>(aq) + 2e<sup>-</sup>  $\rightarrow$  Ni(s)
- D Ni(s)  $\rightarrow$  Ni<sup>2+</sup>(aq) + 2e<sup>-</sup>

# Answer: D

**Study Tips:** How do you know that the cell in Q5.1 is an electrolytic cell? The word "electroplate" tells you that the cell is electrolytic. Which electrode is the "positive" electrode? The anode is ALWAYS the positive electrode and at the anode, oxidation occurs.

The answer can be B or D. It can't be B because the Fe spoon is the cathode i.e. reduction takes place at the Fe spoon. Therefore, the answer is D.

Galvanic and electrolytic cells are compared in the Table 1 below.

	Galvanic cell Electrolytic cell	
Similarities:	Oxidation occurs at anode	Reduction occurs at cathode
Differences:	Anode is negative (-) electrode	Anode is positive (+) electrode

Table 1: Comparison of Galvanic and Electrolytic cells

Cathode is positive (+) electrode	Cathode is negative (-) electrode
Net reaction is exothermic	Net reaction is endothermic

**Study Tip:** You only need to know the information in one of the columns e.g. the shaded column. The information in the unshaded column on the RHS is just the opposite i.e. it can be deduced from the shaded column.

# Activity 5.1:

- 5.1.1 Write down the net cell reaction taking place in electrochemical cell **A** and **B** on page 9.
- 5.1.2 Calculate the standard emf of cell A.
- 5.1.3 Is the net reaction in cell **A** exothermic or endothermic? Give a reason for your answer.

The simplified diagrams below represent two electrochemical cells, **A** and **B**. A concentrated copper(II) chloride solution is used as electrolyte in both cells.



# 5.2 Are **A** and **B** ELECTROLYTIC or GALVANIC cells?

(1)

# Answer: Electrolytic

Study Tip: The two electrodes are connected to a battery/cell or power supply i.e.

they need electrical energy to function. A galvanic cell does not need external electrical energy to function.  $\therefore$  the symbol -|  $\vdash$  is not part of its circuit.

5.3 Which of the electrodes (**P**, **Q**, **R** or **T**) will show a mass increase? Write down a half-reaction to motivate the answer.

(4)

**Study Tip:** "mass increase" means the electrode where REDUCTION occurs. From Table 1 it is the cathode (-) electrode. In the given circuits, the electrodes connected to the negative terminals are the cathodes.  $\therefore$  **Answer** is **Q** and **T**  5.4 Write down the NAME or FORMULA of the product formed at:

5.4.1 Electrode **P** 

**Answer:** Cl<sub>2</sub> or Chlorine gas **Study Tips:** 

- **P** is the positive electrode and negative ions (C<sup>1</sup>) from the electrolyte are attracted to it.
- According to Table 1, **P** is the anode. Oxidation ALWAYS takes place at the anode i.e.  $2 C\ell \rightarrow C\ell_2 + 2\bar{e}$
- Therefore the product formed at **P** is Cl<sub>2</sub>

5.4.2 Electrode **R** 

**Answer:** Cu<sup>2+</sup> or Copper (II) ions

Study Tips: R is also a positive electrode like P. Now explain how you got to

your

Answer. Refer to the Study Tips in 5.4.1.

5.5 Fully explain the answer to QUESTION 5.4.2 by referring to the relative strengths of the reducing agents involved.

(3)

(1)

(1)

# Study Tips:

- Reducing agents are substances that undergo oxidation
- There are two reducing agents that compete to get oxidised viz. Cu from the anode **R** and C*l* ions from the electrolyte that are attracted to **R**, the positive electrode.
- When there is more than one reducing agent available, the strongest reducing agent is oxidized first.
- Since Cu is a stronger reducing agent than Cl<sup>-</sup> (Refer to the table of Standard Reduction Potentials to verify this), it is oxidized to Cu<sup>2+</sup>, first.

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