Western Cape Government
Education

Directorate:
Curriculum FET

2014 Telematics
Grade 12

Physical Sciences
Term 1

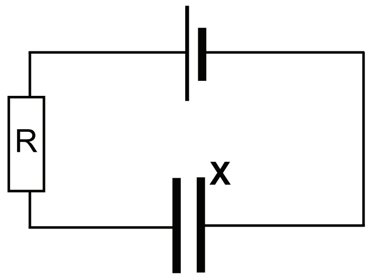
Study Content and Tips

Vertical Projectile Motion • Conservation of Mechanical Energy
Work Energy Theorem • Reaction Rate and Chemical Equilibrium
Galvanic Cell and Electroplating

Price: R4,00

LESSON 1: QUESTION 1: Multiple Choice questions

1.1 A parallel plate capacitor, **X**, with a vacuum between its plates is connected in a circuit as shown below. When fully charged, the charge stored on its plates is equal to Q.



Capacitor **X** is now replaced with a similar capacitor, **Y**, with the same dimensions but with paper between its plates. When fully charged, the charge stored on the plates of capacitor **Y** is …

A zero.

B Equal to Q.

C larger than Q.

D smaller than Q. (2)

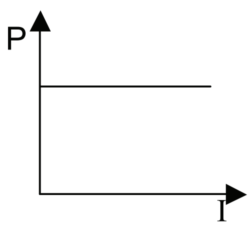
Answer: 1.1 B

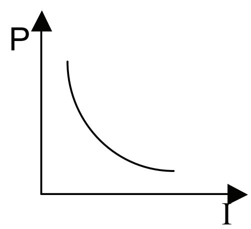
Study Tips: Look at the formula: C = Q/V

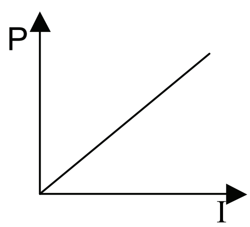
Note that C is constant $\Rightarrow Q \propto V$. $\therefore$ If V has a constant value, then Q also has a constant value so that the value of Q/V still equals C.

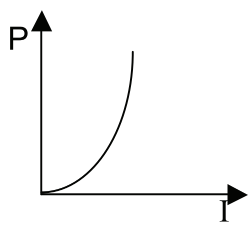
(A learner must know how to reason with proportion)

1.2 Which ONE of the following graphs best represents the relationship between the electrical power and the current in a given ohmic conductor?

A


B


C


D


(2)

Answer: 1.2 D

Study Tips: Note that P = VI

1.2 A: Cannot be the correct answer because if I increases, VI also increases.

1.2 B: Cannot be the correct answer because VI is not inversely proportional to I
i.e. VI x I does not have a constant value

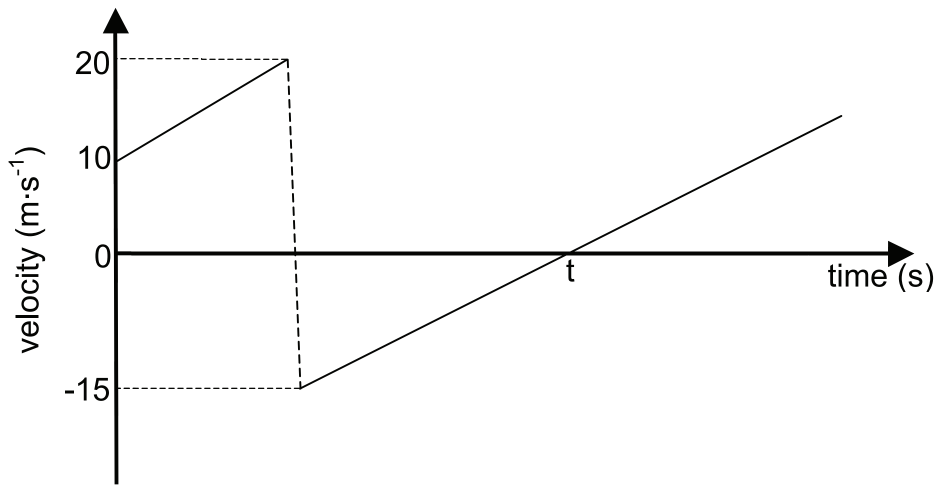
1.2 C: Cannot be the correct answer because as I increases, VI increases but not proportionally because both V and I can increase.
i.e. VI is not directly proportional to I

1.2 D: Is the correct answer. Note that $P = VI = I^2R$ where R is constant. Hence the graph of I^2R versus I, $I \geq 0$, is similar to the graph of ax^2 versus x, $x \geq 0$ which is well known as $y = ax^2$, $x \geq 0$.
(Physics is applied mathematics. The learner must be able to apply his knowledge of the parabola to the graph provided. He should immediately see that the shape in 1.2 D is similar to that of the family of parabolas with equation $y = ax^2$, $x \geq 0$.)

QUESTION 2: VERTICAL PROJECTILE MOTION

The innovations made to the way this topic is examined surprised our learners.

A ball of mass 0,15 kg is thrown vertically downwards from the top of a building to a concrete floor below. The ball bounces off the floor. The velocity versus time graph below shows the motion of the ball. Ignore the effects of air friction. TAKE DOWNWARD MOTION AS POSITIVE.



2.1 From the graph, write down the magnitude of the velocity at which the ball bounces off the floor. (1)

Advice: First Read the stem of the question and study the graph. The motion of the ball written in the stem is illustrated by the graph. Note that the SIGN CONVENTION IS PRESCRIBED AS *"downwards is positive".*

Now write down the information that you can deduce from the graph:

- The initial velocity of the ball is 10 $m.s^{-1}$, downwards. The initial time is 0 s.
- The velocity of the ball when it reached the floor is 20 $m.s^{-1}$
- The ball bounces off the floor with a velocity of - 15 $m.s^{-1}$. The "negative sign" means the velocity of the ball is upwards according to the sign convention given i.e. The initial velocity for the upward motion of the ball is 15 $m.s^{-1}$, upwards.
- Going upwards the ball comes to rest after **t** seconds. It then falls downwards
- Note that the vertical broken line is not perpendicular to the time axis. This shows that there was a time delay before the ball bounces upwards,

After this try and answer the questions asked.

2.1: Answer : 15 $m.s^{-1}$

Study Tips: Refer to the 3rd bullet for the answer. Note that the magnitude of the velocity is requested, therefore the negative sign, that indicates the direction of the ball, is not required.

2.2 Is the collision of the ball with the floor ELASTIC or INELASTIC? Refer to the data on the graph to explain the answer. (3)

2.2 **Answer:** Inelastic. The speed/velocity of the ball after it strikes the floor is less than its speed before striking the floor. ∴Kinetic energy is not conserved.

OR Prove by calculation that kinetic energy is not conserved.

$\Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$= \frac{1}{2}(0,15)(\underline{15})^2 - \frac{1}{2}(0,15)(\underline{20})^2$ ✓

$= - 13,13$ J ✓

$K_i \neq K_f$ ✓

Study Tips: By definition, an inelastic collision is a collision in which kinetic energy is not conserved i.e. $K_{before\ collision} \neq K_{after\ collision}$ i.e. $K_i \neq K_f$. The answer to this question depends on the definition of an inelastic collision.

(As a learner you must know your definitions off by heart. Ability to memorise is a basic requirement in a Physical Sciences examination.)

2.3 Calculate the:

2.3.1 Height from which the ball is thrown (4)

2.3.1: **Answer:**

Method 1: Using equations of motion: Given: v_i = 10 m.s^{-1}, v_f = 20 m.s^{-1}, g = 9,8 m.s^{-2}. To be calculated: Δy the height from which the ball is thrown

Answer:
$v_f^2 = vi^2 + 2a\Delta y$ ✓
$(20)^2$ ✓ $= \underline{(10)^2 + 2(9,8)\Delta y}$ ✓
$\therefore \Delta y = 15,31$ m ✓

Method 2: Use the Work-Energy Theorem. **Do this on your own.**

Method 3: Use the Principle of conservation of mechanical energy. **Do this on your own.**

Study Tips: Method 1: (NOTE: You cannot use the area under the graph/straight line to calculate Δy because time is not provided.) **Tips on how to obtain the correct formula that can be used in this calculation and other calculations:**

Write down for each quantity you are given, its symbol, value and sign (+ or -) according to the sign convention provided (Or chosen): DOWNWARD MOTION POSITIVE means all vectors with direction downwards are positive, and those directed upwards are negative. v_i, v_f and g have directions downwards and are +ve.

GIVEN: v_i = 10 m.s^{-1}, v_f = 20 m.s^{-1}, g = 9,8 m.s^{-2}. TO BE CALCULATED: Δy

CHOOSE THE EQUATION OF MOTION THAT CONTAINS THE 4 SYMBOLS viz.

$v_f^2 = vi^2 + 2a\Delta y$ (This is the correct equation to use)

Note the following characteristics of equations of motion and when to use them.

(a) Each equation has 4 variables
(b) To use any one of the equations of motion in a calculation, the values of three variables must be known.
(c) The fourth variable is the one you want to calculate.
(d) The equations of motion can only be used when acceleration is UNIFORM or CONSTANT and has a non-zero value.
(e) When velocity is uniform, acceleration is zero, and the following equation can only be used: $\Delta v = \Delta x / \Delta t$
(f) The equation at (e) can be used to find resultant velocity. In this case Δx must be the RESULTANT DISPLACEMENT.
(g) The equation at (e) can also be used to:
(i) Find the speed of an object. In this case Δx is the DISTANCE travelled.
(ii) Find the average speed of a moving object. In this case Δx is the sum of individual distances that make up the object's motion.
(h) When any movement involving vector quantities has both upward (or forward) and downward (or backward) motions, a SIGN CONVENTION MUST BE USED. In this question the sign convention is: DOWNWARD MOTION IS POSITIVE. In the answer all vectors have downwards direction and are ∴positive.
(i) The SAME sign convention must be used to solve all the problems related to the object's motion.

(j) Do not change the subject of the formula at the first step of your answer (or any other calculation). Follow the following steps:

STEP 1: Write down the equation viz. $v_f^2 = vi^2 + 2a\Delta y$

STEP 2: Substitute values for symbols: $(20)^2 = (10)^2 + (2)(9,8)\Delta y$

STEP 3: Make Δy the subject of the formula: $\Delta y = [(20)^2 - (10)^2] / (2)(9,8)$

STEP 4: Write down the answer: $\therefore\ \Delta y = 15,31$ m

FOLLOW THIS PROCEDURE IN ALL CALCULATIONS in the syllabus.

2.3.2 Magnitude of the impulse imparted by the floor on the ball (3)

Answer:

$F_{net}\Delta t = \Delta p$

$F_{net}\Delta t = mv_f - mv_i$ ✓Any one

$\Delta p = mv_f - mv_i$

$= 0,15(-15 - 20)$ ✓

$= -5,25$ N·s (or $-5,25$ kg·m·s^{-1})

Magnitude = 5,25 N·s or 5,25 kg·m·s^{-1}✓

Discussion: You must know which formula to use, ALWAYS. Follow the same procedure provided to obtain the equation you should use at method 1 of the answer to 2.3.1. Impulse is defined as the product $F_{net}\Delta t$. As is, $F_{net}\Delta t$ cannot be used to solve this problem because the values of F_{net} and Δt are not provided on the graph. Fortunately, $F_{net}\Delta t = m\Delta v$ and the product $m\Delta v$ can be obtained from the graph. The "=" means that the value calculated for $m\Delta v$ equals that of $F_{net}\Delta v$.
NOTE that momentum is a vector quantity and that the ball has upward and downward motion. Therefore a SIGN CONVENTION is needed. In this question it is provided in the question as DOWNWARDS IS POSITIVE. Verify that v_f is -15 because the ball is moving upwards and that v_i is 20 because the ball is moving downwards i.e. $\Delta v = v_f - v_i = (-15 - (+20)) = -15 - 20$

2.3.3 Magnitude of the displacement of the ball from the moment it is thrown until time *t* (4)

Answer:

Displacement of ball = Ball's resultant displacement

v_i has upward direction and is –ve. g has downward direction and is +ve.

Displacement from floor to maximum height:

$v_f^2 = v_i^2 + 2a\Delta y$✓

$(0)^2 = (-15)^2 + 2(9,8)\Delta y$ ✓

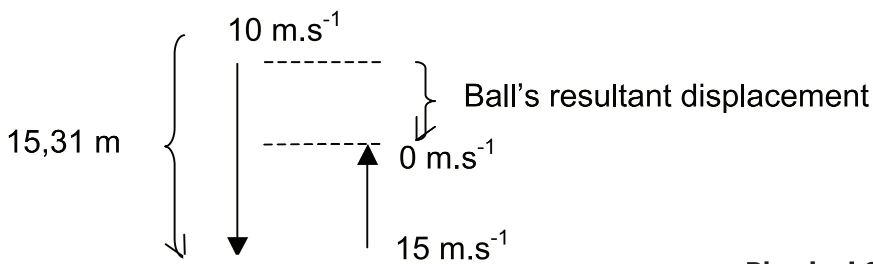
$\Delta y = -11,48$ m

Resultant displacement

$= -11,48 + 15,3$ ✓

$= 3,82$ m ✓

Study Tips: STEP 1: First understand the question. Draw a sketch:



STEP 2: Identify a procedure to calculate the ball's displacement. A procedure that works is: Calculate the vertical displacement of the ball after it bounced. Subtract this answer from 15,31 m to obtain the final answer.

NOTES: **Resultant displacement is a sum of individual displacements**. This fact is applied to obtain the answer: Resultant displacement = Δy_{down} + Δy_{up}

= 15,3 + (-11,48) = 3,82 m

The positive sign of the answer says the direction of the resultant displacement is downwards. (This direction is not required because the question asks for magnitude.)

STEP 3: Again, know which formula to use. Follow the same procedure provided to obtain the equation you should use at method 1of the answer to 2.3.1.

STEP 4: Follow the 4 steps at (j) in the discussion of the answer to 2.3.1.

2.4 Sketch a position versus time graph for the motion of the ball from the moment it is thrown until it reaches its maximum height after the bounce. USE THE FLOOR AS THE ZERO POSITION.

Indicate the following on the graph:

- The height from which the ball is thrown (4)
- Time *t* **[19]**

Answer:

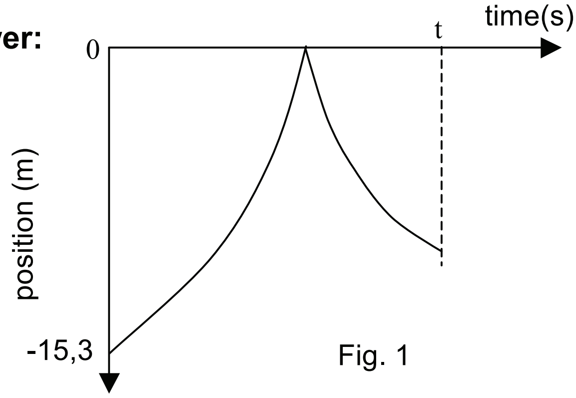


Fig. 1

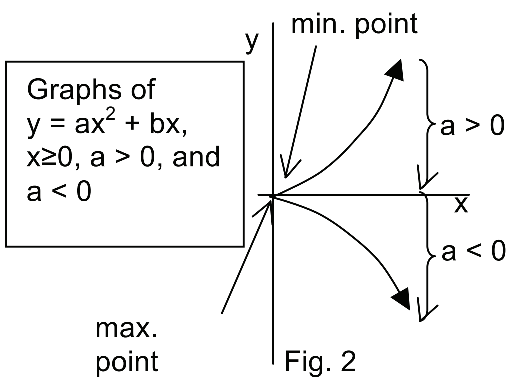


Fig. 2

Study Tips: A position-time graph differs from a displacement-time graph because the former is drawn w.r.t. a reference point. A frame of reference in Physics refers to a co-ordinate system used to represent and measure the position and orientation of a moving object at different times.

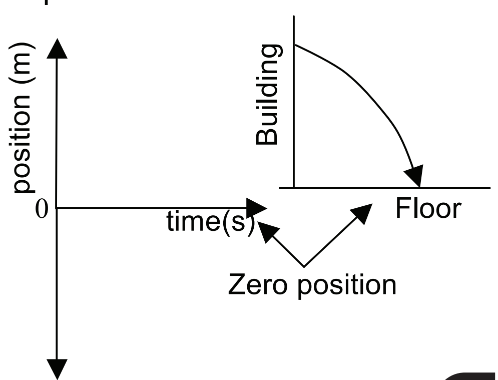
STEP 1: Draw a position-time co-ordinate system.

STEP 2: Identify the zero position

It will be along the time axis.

STEP 3: Determine the orientation of the curve.

NOTES: The curve is a parabola. The orientation of a parabola is determined by the SIGN of the co-efficient of x^2. When it is positive, the parabola has a minimum point. Refer to Fig. 2

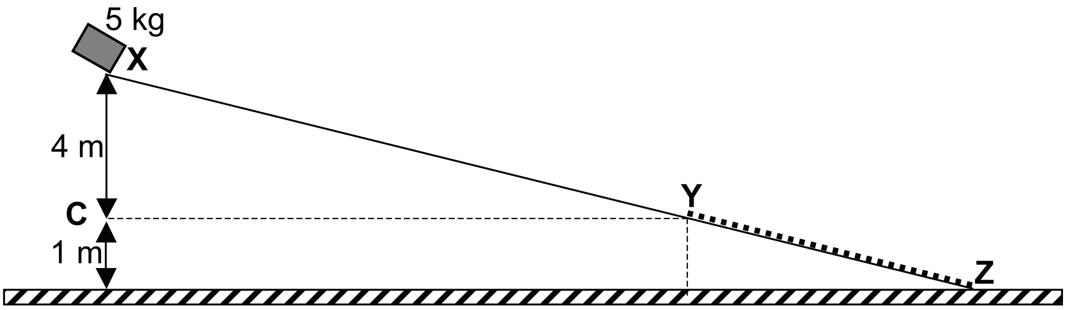


Similarly in Physics, the SIGN of the co-efficient of t^2 determines the position-time graph's orientation. Since down is positive, g is positive, and the curve is thus a parabola with a minimum point.

STEP 4: Sketch the position-time graph. Refer to Fig. 1 for the answer.

LESSON 2: QUESTION 3 WORK-ENERGY THEOREM AND CONSERVATION OF MECHANICAL ENERGY

A 5 kg rigid crate moves from rest down path **XYZ** as shown below (diagram not drawn to scale). Section **XY** of the path is frictionless. Assume that the crate moves in a straight line down the path.



3.1 State, in words, the *principle of the conservation of mechanical energy*. (2)

Answer

The total mechanical energy remains constant / is conserved ✓
in a closed / isolated system / in absence of external forces /non-conservative forces. ✓
OR
The sum of the potential and kinetic energy of a system remains constant ✓
in a closed/isolated system. ✓

Study Tips

Definition**: Mechanical energy (ME) is the SUM of the potential energy and kinetic energy of an object.** In symbols: ME = U + K or ME = mgh + ½ mv^2
ME is conserved only in the ABSENCE of external forces that can act on the system such as friction, applied forces and others.

3.2 Use the principle of the conservation of mechanical energy to calculate the speed of the crate when it reaches point **Y**. (4)

Answer

$E_{mechanical}$ at X = $E_{mechanical}$ at Y
$(E_p + E_k)X = (E_p + E_k)Y$ ✓
$(mgh + ½ mv^2)X = (mgh + ½ mv^2)Y$
$5(9,8)(5) + ½(5)(0^2)$ ✓ $= (5)(9,8)(1) + ½(5)v_f^2$ ✓
$v = 8,85\ m·s^{-1}$ ✓

OR

$E_{mechanical}$ at X = $E_{mechanical}$ at Y
$(E_p + E_k)X = (E_p + E_k)Y$ ✓
$(mgh + ½ mv^2)X = (mgh + ½ mv^2)Y$
$5(9,8)(4) + ½(5)(0^2)$ ✓ $= (5)(9,8)(0) + ½(5)v_f^2$ ✓
$v = 8,85\ m·s^{-1}$ ✓

Study Tips

When ME is conserved, $(U + K)_i = (U+K)_f$ everywhere in the closed system. In particular, $(U + K)_X = (U+K)_Y$. If you use the formula: $U_{top} = K_{bottom}$ you will be penalised because it is a principle error. Note that U = E_p = mgh, and K = E_k = ½ mv^2 i.e. U is the potential energy and K is the kinetic energy of the crate. Energy is a scalar quantity and ∴ there is no need for a sign convention.

NOTE: **ME is conserved if and only if a conservative force is the only force acting on an object.**

Definition: A conservative force is a force that does work on an object that is independent of the path that the object on which it does work, moves.

Examples
F_g (Force of gravity) or w (weight) is an example of a conservative force. All other forces acting on an object such as friction and applied forces are non-conservative forces.

Study the diagram at the beginning of this question. Ignore friction if the crate is allowed to fall from X to C. Then:

- F_g, a conservative force, is the only force acting on the crate.
- $ME_X = ME_Y = ME_C$. **Prove by calculation that this is true**.
- The speed of the crate at Y is equal to the speed of the crate at C. **Prove this by calculation**
- The work done by F_g to move the crate from X to Y has the same value as the work done to move the crate from X to C. **Prove this by calculation.**

On reaching point **Y**, the crate continues to move down section **YZ** of the path. It experiences an average frictional force of 10 N and reaches point **Z** at a speed of 4 $m·s^{-1}$.

3.3 APART FROM FRICTION, write down the names of TWO other forces that act on the crate while it moves down section **YZ**. (2)

Answer

Weight / gravitational (force) / (force of) gravity ✓
Normal force ✓

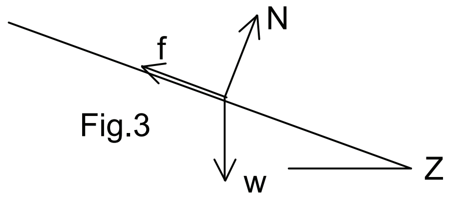


Fig.3

Study Tips
Draw a diagram to show all the forces acting on the crate. Refer to Fig. 3. This will help you answer Q3.5.

3.4 In which direction does the net force act on the crate as it moves down section **YZ**? Write down only from '**Y** to **Z**' or from '**Z** to **Y**'. (1)

Answer
From Z to Y

Study Tips
Friction acts in opposite direction to the crate's motion.

3.5 Use the WORK-ENERGY THEOREM to calculate the length of section **YZ**. (5)

Answer

$W_{net} = \Delta K$ ✓
$W_w + W_f + W_N = ½m(v_f^2 – v_i^2)$ ✓
$mg\Delta y\cos0° + f\Delta x\cos180° + 0 = ½\, m(v_f^2 – v_i^2)$
(5)(9,8)(1)(1) ✓ + (10)Δx(-1) ✓ = ½(5)(42 – 8,852) ✓
Δx = 20,48 m ✓

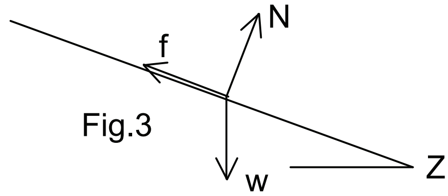


Fig.3

Study Tips

Refer to Fig. 3. Note that no angle between the plane and the horizontal at Z is provided. However, there is sufficient information in the question to answer the questions asked without this angle. Only “f” and “w” do work on the crate. “f” acts over a distance Δx along the plain’s surface, and “w” acts over a distance of 1 m, vertically downwards.

Another crate of mass 10 kg now moves from point **X** down path **XYZ**.

3.6 How will the velocity of this 10 kg crate at point **Y** compare to that of the 5 kg crate at **Y**? Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)

Answer

Equal to

Study Tips

From $(mgh + ½\, mv^2)_X = (mgh + ½\, mv^2)_Y$, we obtain:

$$m_X\,(gh + ½\, mv^2)_X = m_Y\,(gh + ½\, mv^2)_Y$$

i.e. $(gh + ½\, v^2)_X = (gh + ½\, v^2)$ …..(1) (because $m_X = m_Y$)

Equation 1 shows that the velocity at Y is independent of the mass of the crate i.e. that mass (m) does not appear in equation 1.

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Physical Sciences Term 2

Study Content and Tips

Vertical Projectile Motion • Conservation of Mechanical Energy
Work Energy Theorem • Reaction Rate and Chemical Equilibrium
Galvanic Cell and Electroplating

LESSON 3: QUESTION 4: ONE WORD ITEMS

Give ONE word/term for each of the following descriptions. Write only the word/term next to the question number (1.1–1.5) in the ANSWER BOOK.

4.1 The industrial preparation of nitrogen gas from liquid air (1)

4.2 The removal of water from a compound during a reaction (1)

4.3 A theory used to explain how factors, such as temperature, change the rate of a reaction (1)

4.4 The general term used to describe a substance that donates electrons to another substance (1)

4.5 The general term used to describe a class of organic compounds in which one member differs from the previous one by a CH_2 group (1)

[5]

Answers

4.1 Fractional distillation 4.2 Dehydration 4.3 Collision theory
4.4 Reducing agent 4.5 Homologous series

Study Tips

In contrast to Physics which is applied mathematics, Chemistry tests your ability to remember content to a greater extent. The One- Word-Items are testing memory and recall. You need to have a method or strategy to remember and recall this content. Refer to **Study Tips: HOW TO MEMORISE SUBJECT CONTENT USING REPETITION** on page 15 for a method.

LESSON 3: QUESTION 5: REACTION RATE

A hydrogen peroxide solution dissociates slowly at room temperature according to the following equation:

$$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g)$$

During an investigation, learners compare the effectiveness of three different catalysts on the rate of decomposition of hydrogen peroxide. They place EQUAL AMOUNTS of sufficient hydrogen peroxide into three separate containers. They then add EQUAL AMOUNTS of the three catalysts, **P**, **Q** and **R**, to the hydrogen peroxide in the three containers respectively and measure the rate at which oxygen gas is produced.

5.1 For this investigation, write down the:

5.1.1 Independent variable (1)

5.1.2 Dependent variable (1)

Answers

5.1.1 (Type of) catalyst OR **P**,**Q** and **R**✓ (1)

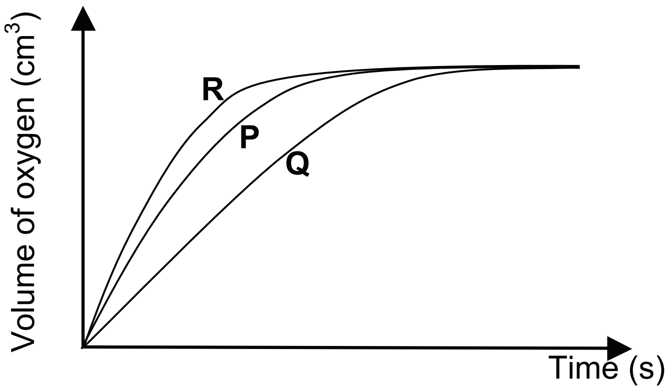
5.1.2 Rate (of reaction) ✓ (1)

Study Tips Definitions**: The independent variable is the physical quantity that you** CHANGE **in the experiment. The dependent variable is the physical quantity you are**

MEASURING **in the experiment.**

Go through the answers and check if each complies with its definition.

The results obtained are shown in the graph below.

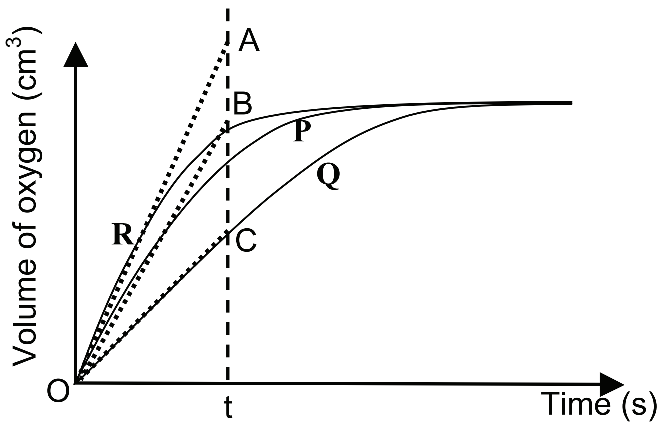


5.2 Which catalyst is the most effective? Give a reason for the answer. (2)

Answer
R ✓
Fastest rate / Steepest (initial) gradient or slope. /Produces oxygen fastest / reaches completion fastest OR faster OR in a shorter time ✓

Study Tips
Before you try the answer you need to know the definition of reaction rate applied to this reaction.
Definition: Reaction rate is the change in the volume of O_2(g) produced divided by the change in time i.e. Reaction rate = $\Delta V/\Delta t$

Study the diagram below. It's intended to help you answer Q5.2 and similar questions in past and future examination question papers.



Look at the broken lines AO, BO and CO that show where each curve is initially straight. Each line has:

- A gradient viz. At/Ot, Bt/Ot and Ct/Ot. Since Ot has a constant length, it is easy to see that At/Ot > Bt/Ot > Ct/Ot. This means that catalyst **R** gives the largest reaction rate because it's curve has the LARGEST gradient. In Chemistry we describe this by saying: "The catalyst **R** gives the largest reaction rate because the gradient of the curve given by **R is the STEEPEST**"

- A slope. Slope is a synonym for gradient. ∴an alternative answer is: "The catalyst **R** has the highest reaction rate because the slope of the curve for catalyst **R is the STEEPEST**"

These are two ways in which you should explain your answer.

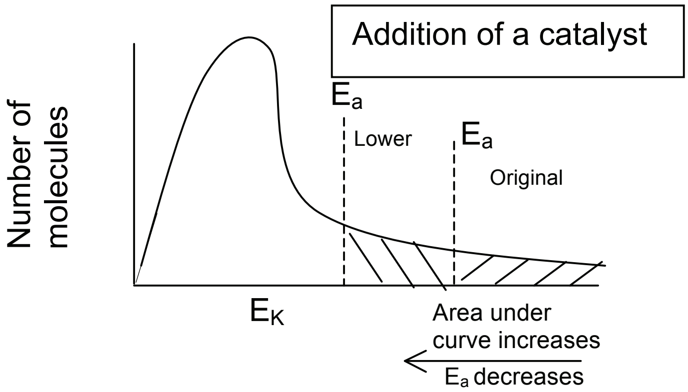
5.3 Fully explain, by referring to the collision theory, how a catalyst increases the rate of a reaction. (3)

Answer

- A catalyst provides an alternative pathway of lower activation energy. ✓
- More molecules have sufficient/enough kinetic energy. ✓
  OR
  More molecules have kinetic energy equal to or greater than the activation energy.
- More effective collisions per unit time. ✓ / Rate of effective collisions increases.

Study Tips

Study the Maxwell-Boltzmann curve below. Use the curve to check that the answer to Q5.3 is correct. Use the curve to answer similar questions in the past and the future.



A catalyst provides an alternative pathway for the reaction which has a lower E_a. With the catalyst more molecules have E_K greater than or equal to E_a (Shaded area under the curve is larger). There are more effective collisions per unit time. Therefore the addition of a catalyst increases reaction rate.

In another experiment, the learners obtain the following results for the decomposition of hydrogen peroxide:

TIME (s)	H_2O_2 CONCENTRATION ($mol \cdot dm^{-3}$)
0	0,0200
200	0,0160
400	0,0131
600	0,0106
800	0,0086

5.4 Calculate the AVERAGE rate of decomposition (in $mol \cdot dm^{-3} \cdot s^{-1}$) of $H_2O_2(aq)$ in the first 400 s. (3)

Answer: Average rate = $\frac{[H_2O_2]}{t}$

$= \frac{0{,}0131 - 0{,}0200}{400 - 0}$ ✓ ✓

$= -1{,}73 \times 10^{-5}\ mol \cdot dm^{-3} \cdot s^{-1}$ ✓

OR Average rate = $-\left(\frac{[H_2O_2]}{t}\right)$

$= -\left(\frac{0{,}0131 - 0{,}0200}{400 - 0}\right)$ ✓ ✓

$= 1{,}73 \times 10^{-5}\ mol \cdot dm^{-3} \cdot s^{-1}$ ✓

Study Tips

Refer to the definition of reaction rate on page 3. Apply this definition to Q5.4. It will give the equation:

$$\text{Average (reaction) rate} = \frac{[H_2O_2]}{t} \quad \dots (1)$$

NOTES

- In science, "rate" refers to a process taking place in a "certain time"
- Δ (or delta) means: "a change in" or in symbols: $\Delta[H_2O_2] = [H_2O_2]_{final} - [H_2O_2]_{initial}$
- Similarly $\Delta t = t_{final} - t_{initial}$. Applied to time in the table $\Delta t = t_{final} - t_{initial} = 400 – 0 = 400$ s
- Similarly, applied to concentration in the table: $\Delta[H_2O_2] = [H_2O_2]_{final} - [H_2O_2]_{initial}$ = 0.0131 – 0,0200 = - 0, 0069 $mol.dm^{-3}$

Now use equation (1) and verify that the answer to Q5.4 is ± 1,73 x 10^{-5} $mol·dm^{-3}·s^{-1}$.

Look at the equation for the reaction viz. $2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g)$

As time progresses, the concentration of reactants decreases and the concentration of products increases. If equation (1) is applied to the product $O_2(g)$, the rate of the reaction will be 1,73 x 10^{-5} $mol·dm^{-3}·s^{-1}$ i.e. the answer has the same magnitude but opposite sign. According to IUPAC, reaction rate is ALWAYS POSITIVE. Applying IUPAC's approach, equation (1) becomes

$$\text{Average rate} = -\left(\frac{[H_2O_2]}{t}\right) \quad \dots (2)$$

Equation (2) is applied to obtain the second answer to Q5.4 on page 4.

5.5 Calculate the mass of oxygen produced in the first 600 s if 50 cm^3 of hydrogen peroxide decomposes in this time interval. (5)

[15]

Answer

<u>**1st find Δn (H_2O_2) when Δt = 600 s:**</u>

$$-\Delta c = -\left(\frac{n}{V}\right) ✓$$

$$-(0{,}0106-0{,}0200) = -\frac{n}{50\times10^{-3}-0} ✓$$

∴ Δn = 4,7 x 10^{-4} mol H_2O_2

<u>Then calculate n and m:</u>

$n(O_2) = ½n(H_2O_2) = ½(4{,}7 \times 10^{-4})$ ✓

= 2,35 x 10^{-4} mol

$$n(O_2) = \frac{m}{M}$$

$$2{,}35 \times 10^{-4} = \frac{m}{32} ✓$$

∴ $m(O_2)$ = 7,52 x 10^{-3} g

= (0,008 g) = (0,01 g) ✓

Study Tips

Use the same technique at Q2.3.1, method 1 to solve this problem.

Given: Δt = 600 – 0 ⇒ Δc = 0,0106 – 0,0200

ΔV = 50x10^{-3} – 0

Then Δn = Δc x ΔV is also given

To calculate: m = ? Use the formula $n = \frac{m}{M}$

NOTES

- The answer involves the use of more than one formula
- "Δ" has the same meaning as noted at the top of this page.
- Both Δc and Δn are negative
- Calculate $\Delta n(H_2O_2)$ using Δn = Δc x ΔV
- $n(H_2O_2)$ can then be calculated using $n = \frac{m}{M}$

LESSON 4: QUESTION 6: CHEMICAL EQUILIBRIUM

A chemical engineer studies the reaction of nitrogen and oxygen in a laboratory. The reaction reaches equilibrium in a closed container at a certain temperature, **T**, according to the following balanced equation:

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

Initially, 2 mol of nitrogen and 2 mol of oxygen are mixed in a 5 dm^3 sealed container. The equilibrium constant (K_c) for the reaction at this temperature is 1,2 x 10^{-4}.

6.1 Is the yield of NO(g) at temperature **T** HIGH or LOW? Give a reason for the answer. (2)

Answer

Low. Reason: Low K_c value

Study Tips

"yield" refers to "what this reaction produces" i.e. the product NO(g). To judge if the amount of NO(g) is high or low we need to estimate its concentration at **T**. The value of K_c helps us make this estimation. Write down the expression for K_c applied to the given reaction:

$$K_c = \frac{[NO]^2}{[N_2][O_2]} \quad \ldots (3)$$

When $K_c > 1$, $[NO]^2 > [N_2][O_2] \Rightarrow$ the amount of NO(g) is > 1. $\therefore$ yield of NO(g) is high

When $K_c < 1$, $[NO]^2 < [N_2][O_2] \Rightarrow$ the amount of NO(g) is < 1. $\therefore$ yield of NO(g) is low

Finally, since K_c = 1,2 x 10^{-4} = 0, 00012 < 1, the yield of NO(g) is low.

OR

A quicker way is to look at the given K_c value. Since K_c = 1,2 x 10^{-4} = 0, 00012 < 1, the yield of NO(g) is low.

6.2 Calculate the equilibrium concentration of NO(g) at this temperature. (8)

Answer

	N_2	O_2	NO	
Initial quantity (mol)	2	2	0	
Change (mol)	x	x	2x	Ratio ✓
Quantity at equilibrium (mol)	2-x	2-x ✓	2x ✓	
Equilibrium concentration ($mol \cdot dm^{-3}$)	$\frac{2-x}{5}$	$\frac{2-x}{5}$	$\frac{2x}{5}$	Divide by 5 ✓

$$K_C = \frac{[NO]^2}{[N_2][O_2]} \checkmark \ \therefore 1{,}2 \times 10^{-4} \checkmark = \frac{\left(\frac{2x}{5}\right)^2}{\left(\frac{2-x}{5}\right)\left(\frac{2-x}{5}\right)} \checkmark$$

$\therefore x = 0{,}0109$ mol

$\therefore [NO] = \frac{2(0{,}0109)}{5} = 4{,}36 \times 10^{-3}\ mol \cdot dm^{-3}$ ✓ (0,004 $mol \cdot dm^{-3}$)

Study Tips

Use the same technique at Q2.3.1, method 1 to solve this problem.

Given: The reaction $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ is at equilibrium. At the start, mol N_2= $n(N_2)$ = 2 and mol O_2= $n(O_2)$ = 2. Volume of container = 5 dm^3. K_c = 1,2x10^{-4}

To calculate: [NO(g)] at equilibrium.

Write down an equation that contains all this information, viz. equation (3): $K_c = \frac{[NO]^2}{[N_2][O_2]}$

Before equation (3) can be used, you need to 1st determine the mol of NO, N_2 and O_2 at equilibrium. Since none are provided, you need to make an ASSUMPTION to obtain them. Any ONE of the following assumptions will solve this problem:

1. Let $n(N_2)$ that reacted be x OR
2. Let $n(O_2)$ that reacted be x OR
3. Let n(NO) that formed be x

Answer Q6.2 on your own using assumption 2 and 3 separately.

Assumption 1 and 2 are the easiest to work from because they do not give fractions in the mole ratio. We use assumption 1: **NOTE: Use assumption 2 and 3 to get the same answer on your own.**

LET $n(N_2)$ that reacted be x. Now we can determine the concentrations of each substance at equilibrium in terms of x. To do this we must use a table (grid) like the one below.

	N_2	O_2	NO
Mol of each substance at the START (This is provided in the stem of the question)	2	2	0
Mol of each substance that REACTED (**<u>NOTES</u>**: This is determined by the **mol ratio** in the balanced equation. In the balanced equation 1 mol N_2 and 1 mol O_2 react. ∴x mol N_2 and x mol O_2 react.)	x	x	
Mol NO that is PRODUCED (**NOTES**: This is determined by the mol ratio in the balanced equation. In the balanced equation, 2mol NO forms for each 1 mol of N_2 and O_2 that react. ∴If x mol of N_2 and x mol of O_2 reacted, 2x mol of NO formed)			2x
Mol of each substance REMAINING in the container at equilibrium (**NOTES:** Subtract the mol of each substance that reacted, and formed, from their mol at the start. Mol of product(s) remain the same because mol products at beginning is zero)	2-x	2-x	2x
Equilibrium concentration ($mol \cdot dm^{-3}$) (**NOTES:** The volume of the container is 5 dm^3. Now use the formula $c=\frac{n}{V}$ to obtain the equilibrium concentration of each substance in the reaction.	$\frac{2-x}{5}$	$\frac{2-x}{5}$	$\frac{2x}{5}$

Now we can substitute the equilibrium concentrations into equation (3) and find x:

$$1,2 \times 10^{-4} = \frac{\left(\frac{2x}{5}\right)^2}{\left(\frac{2-x}{5}\right)\left(\frac{2-x}{5}\right)} = \frac{\left(\frac{2x}{5}\right)^2}{\left(\frac{2-x}{5}\right)^2}$$

NOTES: To find x: Take the square route of both sides of the equation and simplify. Do not use the corresponding quadratic equation. Refer to the teacher guidelines column on page 125 of the CAPS document.

$$0,0109544 = \frac{2x}{2-x} \Rightarrow 0,0109544(2-x) = 2x \Rightarrow x = 0,0109$$

Finally we can calculate [NO]:

$$\therefore [NO] = \frac{2(0,0109)}{5} = 4,36 \times 10^{-3} \text{ mol·dm}^{-3} \ (0,004 \text{ mol·dm}^{-3})$$

6.3 How will each of the following changes affect the YIELD of NO(g)? Write down only INCREASES, DECREASES or REMAINS THE SAME.

6.3.1 The volume of the reaction vessel is decreased at constant temperature. (1)

Answer
Remains the same

$N_2(g)$	+	$O_2(g)$	⇌	$2NO(g)$
1 mol	+	1 mol		2 mol

∴ Total mol LHS (1 + 1) mol= 2 mol = Total mol RHS

Study Tips
When the volume of the reaction vessel decreases, the pressure exerted on the enclosed gas increases. The equilibrium will shift to the side where molecules can occupy less volume i.e. to the side that has fewer mol molecules. **Since both sides have the same mol molecules, the mol NO(g) remains the same, and hence its yield**. NOTES: Remember: pV = nRT. At the same p(pressure) and T(temperature), V(volume) ∝ n (moles). This means: The volume occupied by the molecules can be deduced from the number of mol (numerical coefficient) of each molecule in the balanced equation.

6.3.2 An inert gas such as argon is added to the mixture. (1)

Answer
Remains the same

Study Tips
NOTES: ONLY GASES ADDED THAT TAKE PART IN THE REACTION CHANGE EQUILIBRIUM CONCENTRATIONS. The argon gas does not react with any reactant or product. Thus the concentration of each substance in the equilibrium mixture remains the same. ∴The mol NO(g) remains the same, and hence also its yield.

6.4 It is found that K_c of the reaction increases with an increase in temperature. Is this reaction exothermic or endothermic? Explain the answer. (3)
[15]

Answer
Endothermic ✓
- An increase in K_C implies an increase in concentration of products. ✓
  OR An increase in K_C implies that the forward reaction is favoured.
  An increase in K_C implies the equilibrium position shifts to the right.
  An increase in temperature favours an endothermic reaction. ✓

Study Tips
Use the same technique at Q2.3.1, method 1 to solve this problem.
Given: K_c of the reaction increases with an increase in temperature.
What is the question to be answered: Is this reaction exothermic or endothermic?
Determine what the given means: According to equation (3) on page 6, the K_c value will increase if [NO] increases. This means that the forward reaction is favoured with an increase in temperature.
Remember this fact: Increase in temperature favours the endothermic reaction.

Now you have all the information to answer the question. Refer to the answer and note how it is written down. Now try and answer the question yourself.

LESSON 5: QUESTION 7: GALVANIC CELL

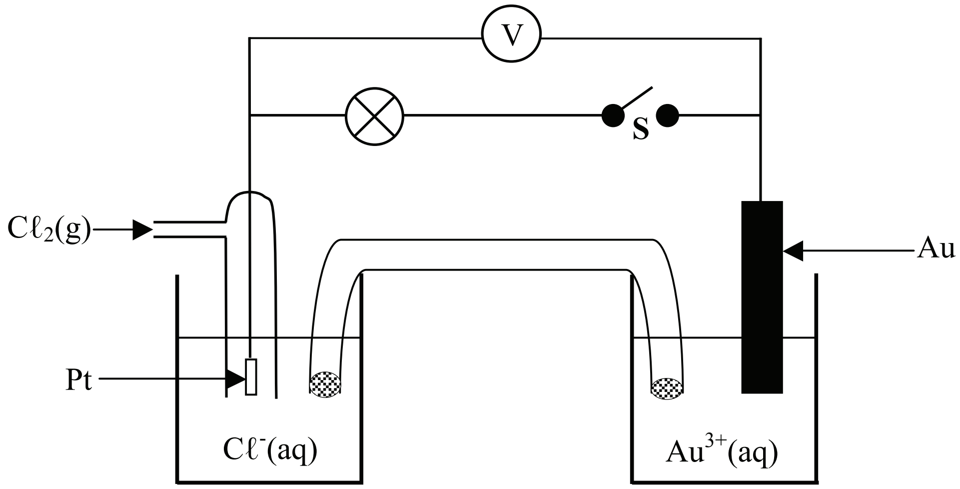
NOTE: Performance in galvanic cells and electrolytic cells is poor and much more has to be done to change this. A weakness is that learners do not know the similarities and differences between galvanic and electrolytic cells. The information below is provided to help our learners.
Study Tips
In the table below, GALVANIC and ELECTROLYTIC CELLS are compared

Table 1: Comparing galvanic and electrolytic cells

Galvanic cell (voltaic cell)	**Electrolytic cell**
Similarities	
• At anode oxidation takes place • At cathode reduction takes place	
Differences	
Chemical energy is converted to electrical energy	Electrical energy is converted to chemical energy
Positive terminal is the cathode	Positive terminal is the anode
Negative terminal is the anode	Negative terminal is the cathode
Net (overall) cell reaction is exothermic	Net (overall) cell reaction is endothermic

The diagram below shows a galvanic cell operating under standard conditions. The net cell reaction taking place when the cell is functioning is:

$$6C\ell^{-}(aq) + 2Au^{3+}(aq) \rightarrow 3C\ell_2(g) + 2Au(s)$$



With switch **S** OPEN, the initial reading on the voltmeter is 0,14 V.

7.1 Write down the:

7.1.1 NAME or FORMULA of the oxidising agent (1)

Answer

Au^{3+} / gold(III) ion ✓

> **Use the word OILRIG to remember a definition of oxidation and reduction:**
>
> **O**xidation **I**s **L**oss of electrons **R**eduction **I**s **G**ain of electrons

Study Tips

1. You need to know what an oxidising agent is.

Definition (1): An oxidising agent is an atom, ion or compound that oxidises another atom, ion or compound whilst it itself is reduced.

2. You need to know what reduction and oxidation are.

Definition (2): Reduction is a GAIN in electrons OR
Definition (3): Reduction is a DECREASE in oxidation number.
Definition (4): Oxidation is a LOSS of electrons OR
Definition (5): Oxidation is an INCREASE in oxidation number

3. In galvanic cells there are two places where the oxidising agent can be found:
   3.1 Left of the arrow in the (net) cell reaction i.e. it is one of the reactants
   3.2 In the half cell called the cathode of the galvanic cell where it is used to make an aqueous solution called the electrolyte
4. Now apply the above information to find the oxidising agent. **Using 3.1**: The net cell reaction is given as: $6C\ell^-(aq) + 2Au^{3+}(aq) \rightarrow 3C\ell_2(g) + 2Au(s)$. Look at the LHS of this reaction: Then either $C\ell^-$ or Au^{3+} is the oxidising agent. Au^{3+} gains $3e^-$s to form Au. $C\ell^-$ cannot gain electrons because $C\ell^-$ and electrons have a negative charge (Like charges REPEL each other). Thus Au^{3+} is the answer.
5. Check if Au^{3+} satisfies definition 1:
   Definition 1: From $2C\ell^- \rightarrow C\ell_2 + 2e^-$ we see that the oxidation number of Chlorine INCREASES from -1 to 0 OR Each chloride ion loses $1e^-$. This means that $C\ell^-$ is oxidised. From $Au^{3+} + 3e^- \rightarrow Au$ we see that the oxidation number of gold DECREASES from +3 to 0 OR Each gold ion gains $3e^-$. This means that Au^{3+} is reduced. Therefore definition 1 is completely satisfied. At the same time definitions 2 to 5 were used in the answer.
6. The half cell called the cathode cannot be used to identify the oxidising agent yet. After Q7.1.2 is solved we will show you how to use the electrolyte in the cathode to identify the oxidising agent.

The method used so far to determine the LOSS or GAIN in electrons in a redox reaction is limited. The oxidation number method is more versatile in doing this and can be used in ALL oxidation-reduction (redox) reactions. The definition of oxidation number and the rules to obey when using oxidation number are provided below. (They are not provided in an exam paper ∴ you need to memorise the rules)

Definition of oxidation number: Is the charge an atom of an element would have in a compound if all bonds were ionic. [Since all bonds are not ionic, the charge is an imaginary charge.]

RULES TO ALLOCATE OXIDATION NUMBERS

1. The oxidation number of a free element = 0
   [E.g. The oxidation number of an atom in each of H_2, O_2, Cl_2, P_4, S_8, and so on is 0]
2. The oxidation number of the hydrogen (H) atom = +1 in all compounds except the hydrides where its oxidation number = -1 [E.g. The oxidation number of H in H_2O, HCl, NaOH, CH_4 and so on is +1. The oxidation number of H in NaH, LiH and so on is -1]

3. The oxidation number of the oxygen (O) atom = -2 in all compounds except the peroxides in which the oxidation number of the O atom = -1 and in compounds of fluorine which is more electronegative than O where its oxidation number is +2. [E.g. The oxidation number of O in H_2O, CO_2, NaOH, and so on is -2. The oxidation number of O in H_2O_2, Na_2O_2, and so on is -1. The oxidation number of O in OF_2 is +2.]
4. The oxidation number of a monatomic ion = its ionic charge [E.g. The oxidation number of Br in Br- is -1, that of Na in Na^+ is +1, that of Mg in Mg^{2+} is +2, that of S in S^{2-} is -2, and so on]
5. In the allocation of oxidation numbers charge is conserved. This means that the sum of the oxidation numbers of the atoms in a neutral compound is zero, while the sum of the oxidation numbers of the atoms in a polyatomic ion is equal to the charge on the polyatomic ion.

Example 1: The oxidation number of S in H_2SO_4 is obtained as follows:

By rule 2, the oxidation number of H is +1.
By rule 3, the oxidation number of O is -2.
By rule 5 (applied to H_2SO_4):

2(+1) + Oxidation number of S + 4(-2) = 0
+2 + oxidation number of S -8 = 0
∴ Oxidation number of S = 0 -2 +8 = +6

Example 2: The oxidation number of Cr in $Cr_2O_7^{2-}$ is obtained as follows:

By rule 3, the oxidation number of O is -2.
By rule 5(applied to $Cr_2O_7^{2-}$):

2(Oxidation number of Cr) + 7(-2) = -2
2(Oxidation number of Cr) -14 = -2
2(Oxidation number of Cr) = -2 +14 = +12

∴ Oxidation number of Cr = $\frac{+12}{2} = +6$

7.1.2 Half-reaction which takes place at the anode (2)

Answer

$2Cl^- \rightarrow Cl_2 + 2e^-$ ✓✓

Study Tips

To answer this question you need to know:

1. What a half-reaction is?

Definition: A half reaction is either a(n) oxidation reaction or a reduction reaction.

2. The reaction that takes place at the anode.
   In Table 1on page 9 under "similarities", it is mentioned that OXIDATION occurs at the ANODE.

Now we are ready to answer Q7.1.2. In the net cell reaction we must identify the oxidation half reaction. We apply definition 4 and 5 to the net cell reaction:

Increase in oxidation number (Oxidation)

LOSS of electrons

$$6Cl^-(aq) + 2Au^{3+}(aq) \rightarrow 3Cl_2(g) + 2Au(s).$$

GAIN in electrons

Decrease in oxidation number (Reduction)

The arrows above the reaction show the oxidation half reaction : $Cl^- \rightarrow Cl_2$. Refer to the Table of Standard Reduction Potentials to complete the reaction. It will give: $2Cl^- \rightarrow Cl_2 + 2e^-$

Study Tips: Q7.1.1 (page 10)

We are now in a position to answer Q7.1.1 by using the electrolyte at the half cell called the cathode:

According to Table 1 on Page 9, reduction takes place at the cathode. According to the answer to Q 7.1.2, $2Au^{3+}(aq) \rightarrow 2Au(s)$ must then be the reaction that takes place at the cathode. According to the diagram in the stem of this question, the electrolyte is $Au^{3+}(aq)$. Thus the substance that forms the aqueous solution is Au^{3+} (or any soluble gold (III) salt e.g. $Au(NO_3)_3$) and it is the oxidising agent.

7.1.3 Cell notation for this cell (3)

Answer

✓ ✓ ✓

$Pt \mid Cl^- \mid Cl_2 \parallel Au^{3+} \mid Au$ OR $Pt \mid Cl_2 \mid Cl^- \parallel Au^{3+} \mid Au$

OR

$Pt(s) \mid Cl^-(aq) \mid Cl_2(g) \parallel Au^{3+}(aq) \mid Au(s)$ OR $Pt(s) \mid Cl_2(g) \mid Cl^-(aq) \parallel Au^{3+}(aq) \mid Au(s)$

Study Tips

(NOTE: The redox pairs in the answer to Q7.1.3 are $Cl_2 \mid Cl^-$ and $Au^{3+} \mid Au$).

Cell notation is a shorter way to represent the cell reaction. The following RULES must be obeyed when writing cell notation:

1. The salt bridge is represented by ||
2. The cathode half cell is ALWAYS written on the right of ||. Use **OAR** to remember this: **O**xidising **A**gent (is written on the) **R**ight.

3. When the cathode contains a redox pair that consists of substances in different phases,| is used to indicate this e.g. Au^{3+}(aq) and Au(s) is written as Au^{3+}(aq) | Au(s). The substance in the solid phase (Au) is ALWAYS written on the outside of |
4. If the substances in the redox pair are in the same phase, then a comma "," is used to indicate this e.g. Fe^{3+}(aq),Fe^{2+}(aq)
5. If the cathode consists of a gas such as H_2(g) that has to be in contact with its ions in water (H^+(aq)), an inert electrode such as Pt is used to achieve this. Then the redox pair together with the inert Pt electrode is written as Pt|H^+|H_2 (or Pt|H_2 |H^+), with Pt on the outside. Again, | is used to separate the different phases.
6. The anode half cell is ALWAYS written on the left of ||
7. Rules 3 to 5 are then applied to the anode half reaction.

Now read the study tips and try to understand the answer to Q7.1.3

7.2 Calculate the standard reduction potential of Au. (4)

Answer:

$E^o_{cell} = E^o_{cathode} – E^o_{anode}$ ✓
0,14 ✓ = $E^o_{cathode}$ - (1, 36) ✓
$E^o_{cathode}$ = 1,50 V ✓

Study Tips:
Follow the same procedure as in method 1 in Q 2.3.1.
Given: Initial cell reading = 0,14 V= E^o_{cell} ; the net cell reaction shows that $2Cl^- \rightarrow Cl_2 + 2e^-$ occurs at the anode and using the Table of Standard Reduction Potentials, read off the E^o value for this half reaction which is 1,36 V. Thus E^o_{anode} = 1,36 V.
To calculate: $E^o_{cathode}$. Identify the formula that contains E^o_{cell}, E^o_{anode} and $E^o_{cathode}$. It is: $E^o_{cell} = E^o_{cathode} – E^o_{anode}$. Now follow the 4 steps at (j) in the answer to Q2.3.1 (in Lesson1, Term 1,

Switch **S** is now closed and the bulb lights up.

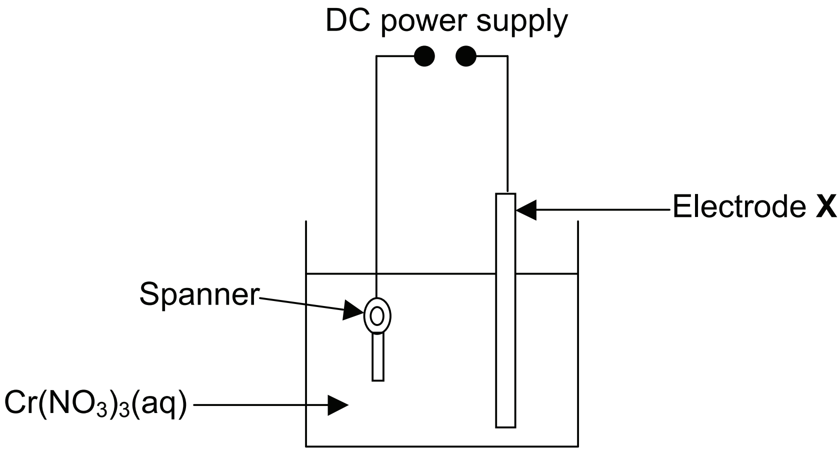
7.3 How will the reading on the voltmeter now compare to the INITIAL reading of 0,14 V? Write down only LARGER THAN, SMALLER THAN or EQUAL TO. Give a reason for the answer. (2)
[12]

Answer
Smaller than ✓
Decrease in potential difference or voltage due to internal resistance of cell or "lost volts". ✓

Study Tips
The circuit with the light bulb is only applicable to answering Q7.3.
When switch **S** is open, the voltmeter measures the potential difference across the two electrodes. When **S** is closed, the cell delivers current that passes through both the internal circuit of the cell and the bulb. The internal circuit of the cell has internal resistance which results in "lost volts" according to the formula E = IR + Ir where Ir = "lost volts".

LESSON 5: QUESTION 8: ELECTROPLATING

The diagram below represents a simplified electrolytic cell used to electroplate a spanner with chromium. The spanner is continuously rotated during the process of electroplating.



A constant current passes through the $Cr(NO_3)_3$(aq) solution and its concentration remains constant during the process. In the process, a total of 0,03 moles of electrons is transferred in the electrolytic cell.

STUDY Tips
The 1st thing to do in an electroplating or electrorefining question is to IDENTIFY ONE OF THE TWO ELECTRODES AS THE POSITIVE (OR NEGATIVE) ELECTRODE (OR AS THE ANODE (OR CATHODE)). Then the other electrode will just be the opposite. You need to know the DIFFERENCE between a galvanic cell and an electrolytic cell well to be able to do this. Consult Table 1 on page 9 for these differences.

EXAMPLE

IN ELECTROPLATING (OR ELECTROREFINING) THE BEST PLACE TO BEGIN IS AT THE OBJECT THAT MUST BE ELECTROPLATED (OR THE ELECTRODE THAT IS THE REFINED / PURIFIED METAL) viz. THE SPANNER in this question. To plate the spanner with Cr, Cr^{3+} IONS IN THE ELECTROLYTE ($Cr(NO_3)_3$(aq)) must be REDUCED to Cr. THEREFORE THE SPANNER IS THE CATHODE because reduction must take place here. According to Table 1 on page 9, the cathode is the NEGATIVE electrode i.e. the spanner is also the negative electrode. OR the spanner must be the negative electrode because POSITIVE IONS (Cr^{3+} IONS) MUST BE ATTRACTED TO IT.
Now write cathode and "-" at the spanner in the diagram provided in the stem of this question and then answer ALL the questions in question 8.

8.1 Define the term *electrolysis*. (2)

Answer
The chemical process in which electrical energy is converted to chemical energy.✓✓
OR
The use of electrical energy to produce chemical change.

Study Tips: HOW TO MEMORISE SUBJECT CONTENT USING REPETITION
Definitions, principles, laws, rules, properties, etc. are aspects of subject content that you must be able to reproduce. Therefore you need a method to memorise them all. Here is a method (a 'definition' is used as an example to show the method):

STEP 1: Read the definition three times (Try to understand and remember it.)
STEP 2: Write it down from your memory on a piece of paper
STEP 3: Compare the actual definition in STEP1 to what you wrote down in STEP 2
STEP 4: Correct your mistakes.
STEP 5: Repeat STEP 1 to 4 until you can reproduce the definition without any mistakes. [It can take 3, 5, and even more repetitions to reproduce definition]

By doing this daily, you can remember all the content that must be memorised in all your subjects and pass examinations easily throughout your life.

NOTES: WE ALL LEARN BY REPETITION (to ride a bicycle, drive a car, play a piano, etc)

8.2 Write down the:

8.2.1 Half-reaction that occurs at the spanner (2)

Answer

$Cr^{3+} + 3e^{-} \rightarrow Cr(s)$ ✓✓

Study Tips

If you follow the study tips and example page 14, then the answer to Q8.2.1 is easy to obtain. In Q8, the spanner is the cathode or negative electrode. Reduction takes place at the cathode in both galvanic and electrolytic cells (Refer to Table 1, on page 9). You should also consult definition 2 and 3 on page 10 on reduction to ensure that you know what reduction is. Remember: the Cr^{3+} ions in the electrolyte are reduced at the spanner i.e. they form Cr(s) on the spanner. Now write down the half reaction.

8.2.2 NAME or FORMULA of the metal of which electrode **X** is made (1)

Answer

Cr / chromium ✓

Study Tips

If you follow the study tips and example on page 14, then electrode **X** is the opposite of the cathode (spanner) i.e. electrode **X** is the anode. NOTE: The Cr^{3+} ions reduced at the cathode will eventually get finished if they are not replaced. There is ∴ a need that electrode **X** produces Cr^{3+} ions. This will happen if electrode **X** is Cr(s) (or chromium) because Cr will then be oxidised to Cr^{3+}.

8.2.3 NAME or FORMULA of the oxidising agent (1)

Answer

Chromium(III) ions / Cr^{3+} ✓

Study Tips

Follow the study tips to obtain the answer to Q7.1.1 on page 10. This question is the same.

8.3 Calculate the gain in mass of the spanner. (4)
[10]

Answer

$n = \frac{m}{M}$ ✓

$\left(\frac{0,03}{3}\right)$ ✓ $= \frac{m}{52}$ ✓ **OR** $0,01$ ✓ $= \frac{m}{52}$ ✓

$\therefore m = 0,52$ g ✓

OR

3 mol e^- .... 52 g ✓ Cr

0,03 mol e^-....... $\left(\frac{0,03}{3}\right)$ ✓ (52) ✓ = 0,52 g. ✓.

Study Tips

Follow the same procedure as in method 1 in Q 2.3.1.

Given: Cr^{3+} + 3□ □ Cr(s); 0,03 mol □s change Cr^{3+} to Cr(s); Molar mass of Cr = M(Cr) = 52

To calculate: The mass of Cr that is plated on the spanner.

Calculation: Identify a formula that contains mol and mass and molar mass. It is $n = \frac{m}{M}$. From the balanced half reaction: 3 mol □s form 1 mol Cr(s) i.e. the mol ratio is 3:1

$\therefore$0,03 mol □s form $\left(\frac{0,03}{3}\right)$ mol Cr(s) = 0,01 mol Cr(s). Now use $n = \frac{m}{M}$ again to find m = mass of Cr gained by spanner: $0,01 = \frac{m}{52}$ $\therefore m = 0,52$ g