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PHYSICAL SCIENCES

GDE MATERIAL

2020



GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

GRADE 12

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GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

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WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15	WEEK 16	WEEK 17	WEEK 18	WEEK 19	WEEK 20	WEEK 21
48.5%	52.5%	58.6%	62.6%	68.7%	70.7%	74.7%	78.8%			
31/03 – 3/04	6- 9 Apr	14 - 17 Apr	20 - 24 Apr	28 – 30 Apr	4 - 8 Mei	11 - 15 Mei	18 – 22 Mei	25 Mei - 12 Junie		
MECHANICS			CHEMICAL CHANGE					Midyear examination		
➤ Vertical projectile motion ➤ Graphs ➤ Equations	➤ Work ➤ Work-energy theorem	➤ Conservation of energy with non-conservative forces present ➤ Calculations ➤ Power ➤ Calculations	➤ Rates of R_x ➤ Factors ➤ Collision theory, Mechanism & catalysis ➤ Measuring rates of R_x ➤ E_A ➤ Maxwell Boltzmann, Graphs	➤ Chem. Equilibrium ➤ Factors ➤ Equilibrium constant ➤ Significance of K_c ➤ Calculations	➤ Le Chatelier's principle ➤ Interpret graphs ➤ Application of chemical equilibrium principles	➤ Acids and base models ➤ Concentrated, dilute, weak, strong acids and bases ➤ Conj. acid-base pairs ➤ K_w ➤ pH scale ➤ pH of salts ➤ Auto-ionisation ➤ Hydrolysis ➤ Reaction equations	➤ Neutralization R_x ➤ pH Calculations ➤ Indicators ➤ Titration ➤ Titration calculations ➤ Application – Chloralkali industry ➤ PRESCRIBED EXPERIMENTWRITE-UP			

SESSION 1 : VERTICAL PROJECTILE

Vertical Projectile Motion in One Dimension (1D) [EXAMINATION GUIDELINES]

- ☛ Explain what is meant by a *projectile*, i.e. an object upon which the only force acting is the force of gravity.
- ☛ Use equations of motion to determine the position, velocity and displacement of a projectile at any given time.
- ☛ Sketch position versus time (x vs. t), velocity versus time (v vs. t) and acceleration versus time (a vs. t) graphs for:
 - ☛ A free-falling object
 - ☛ An object thrown vertically upwards
 - ☛ An object thrown vertically downwards
 - ☛ Bouncing objects (restricted to balls)
- ☛ For a given x vs. t , v vs. t or a vs. t graph, determine:
 - ☛ Position
 - ☛ Displacement
 - ☛ Velocity or acceleration at any time t
- ☛ For a given x vs. t , v vs. t or a vs. t graph, describe the motion of the object:
 - o Bouncing
 - ☛ Thrown vertically upwards
 - ☛ Thrown vertically downward

The following terminologies underpin the TOPIC:

1. Projectile
2. Free Fall
3. Gravitational Force
4. Acceleration due to Gravity.



MULTIPLE CHOICE QUESTIONS

Four options shall always be given as possible answers.

TECHNIQUE IN THE ANSWERING OF MULTIPLE CHOICE QUESTIONS

Step 1: Read the question carefully.

Step 2: Underline the KEY words in the question.

Step 3: Pay attention to words that are CAPITALIZED, or words in ITALICS.

Step 4. Decide whether you are required to recall or use a fact, phenomenon, Definition, unit OR formula.

Step 5. First, delete the answers that are obviously incorrect (**Called Distractors**)

Step 6. Finally select the correct answer from the others that remain. This is called ELIMINATION and is particularly helpful when the answers or options are very close to each other.

MULTIPLE CHOICE QUESTIONS

- 1.1 A stone is thrown vertically upwards into the air. Which combination in the table below shows the correct change in the momentum and the potential energy of the stone? (Ignore the effects of air friction)

	Momentum	Potential energy
A	Increases	Decreases
B	Decreases	Increases
C	Increases	Increases
D	Decreases	Stays constant

(2)



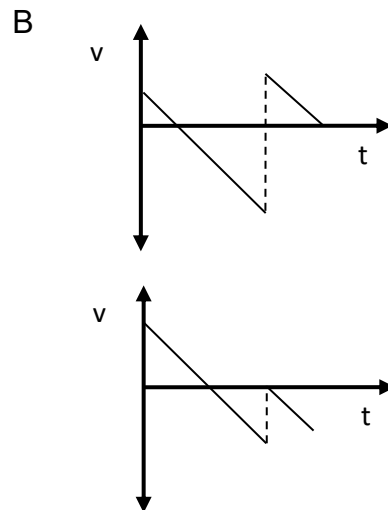
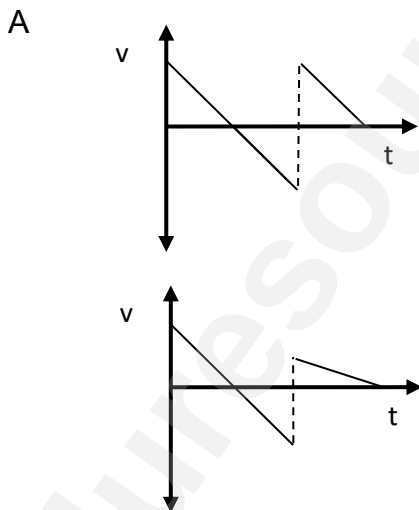
- 1.2 A ball is dropped from height h above the ground and reaches the ground with kinetic energy E . From which height must the ball be dropped to reach the ground with kinetic energy $2E$? (Ignore all effects of friction.)

A $2h$
 B $3h$
 C $4h$
 D $8h$

(2)

- 1.3 A ball is projected vertically upwards from the ground. It returns to the ground, makes an elastic collision with the ground and then bounces to a maximum height. Ignore air resistance.

Which ONE of the following velocity-time graphs CORRECTLY describes the motion of the ball?



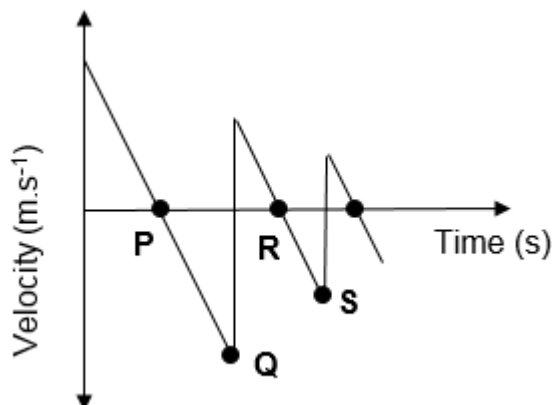
(2)

- 1.4 A learner drops an object from the top of a cliff. One second later she drops another identical object. While both objects are in free fall, the distance between them

A. decreases
 B. remains constant
 C. increases
 D. at first increases and then decreases. (2)



1.5 A ball is thrown vertically upwards from a certain height above the floor. The ball bounces a few times from the floor. The velocity–time graph below represents the motion of the bouncing ball from the moment it was thrown. Ignore the effects of friction.



Which point (**P**, **Q**, **R** or **S**) on the graph represents the coordinates of the maximum height after the first bounce?

- A. P
- B. Q
- C. R
- D. S

(2)

STRUCTURED QUESTIONS

PROBLEM SOLVING STRATEGY

Step 1: Read the statement carefully.

Step 2: Make sense of the statement (Draw a diagram)

Step 3: Take direction (upward as +; downward as – OR vice versa)

Step 4: Outline the given data.

Step 5: Identify the suitable formula from the DATA SHEET.

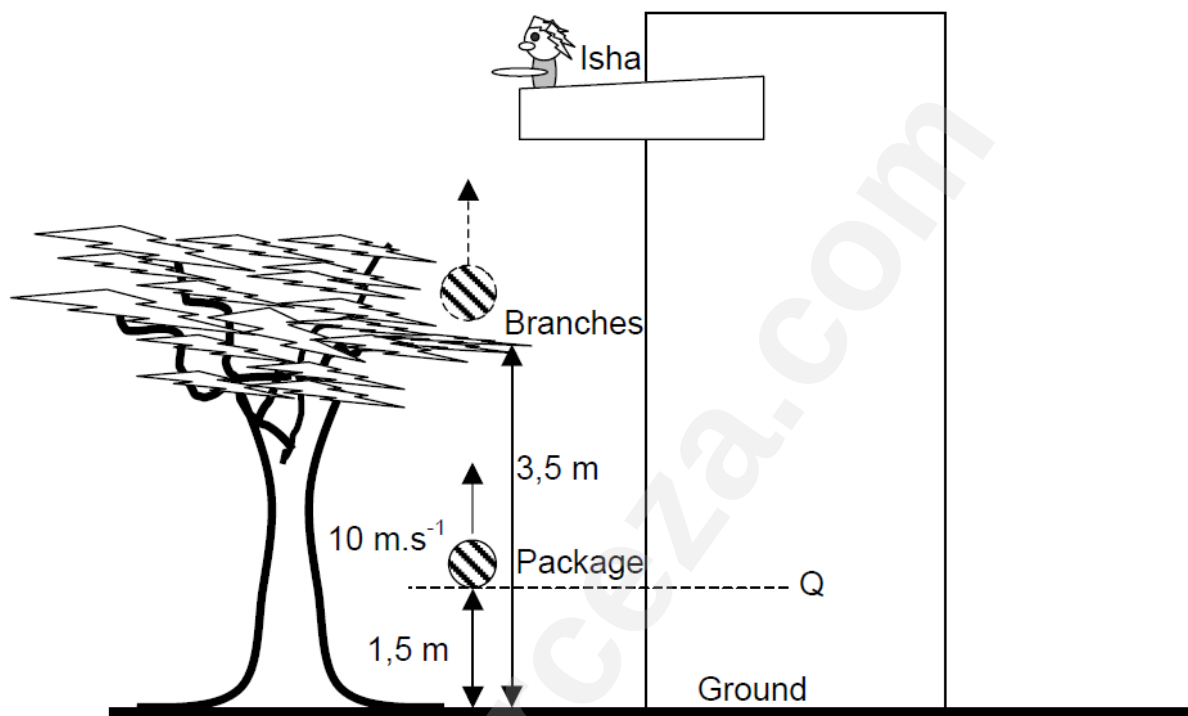
Step 6: Substitute the known values into the formula and solve for unknown variable.

QUESTION 1

Akash, standing on the ground, throws a package, mass 500 g, vertically upwards to Isha, who is on the second-floor balcony of a building. At a height of 1,5m above the ground (point Q), the package leaves his hand at a speed of 10 m.s^{-1} . At a height of 3,5m above the ground, the package



accidentally passes through a thin layer of branches of a tree, but still continues vertically upwards. Ignore the effects of air resistance.



- 1.1 Calculate the maximum height above point Q that the package could have reached, if the branches had not been in the way. **(5m)**
(5)
- 1.2 State, in words, the Law of Conservation of Mechanical Energy. **(3)**
(3)
- 1.2.1 Without using the kinematic equations of motion, calculate the speed of the package just as it reaches the branches. **(7,75m.s⁻¹)**
(7)

The package, on its way upward, leaves the branches at a velocity of 5m.s⁻¹ at a height of 3,60m above the ground.

- 1.3 Calculate the work done by the package in passing through the branches. **(8,77J)**
(5)
- 1.4 Calculate whether Isha, who must catch the package on the balcony at a height of 4,9m above the ground, will be successful. **(4,85m)**
(5)

[25]

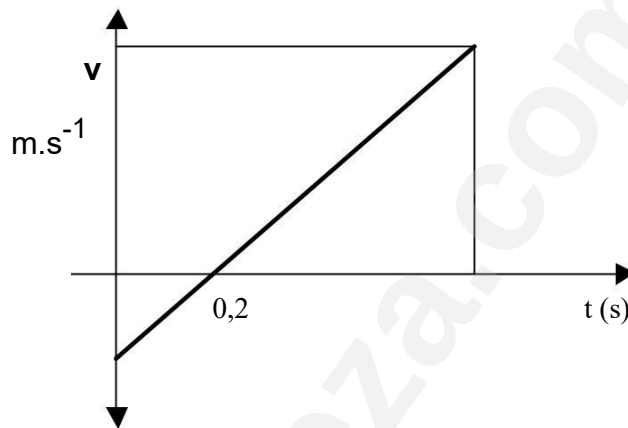
QUESTION 2



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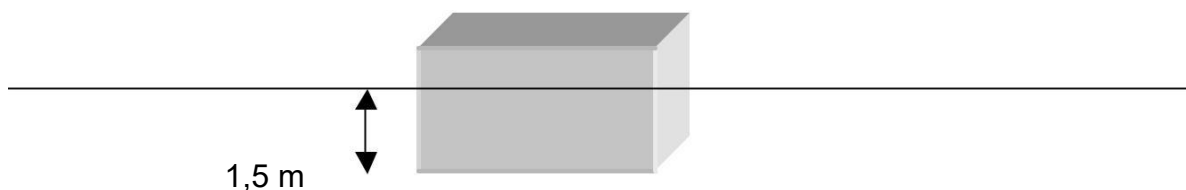
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A crane in the East London harbor lifts a crate, mass 300 kg, from the deck of a ship. It then moves the crate horizontally above the surface of the water and stops. The crate is now lifted vertically upwards at a constant speed. When the crate is 30 m above the surface of the water, while it is still moving upwards, the cable holding the crate snaps. The velocity-time graph below represents the motion of the crate from the moment the cable snaps until it hits the water. **Downward motion** is taken as positive and the effects of air resistance can be ignored.



- 2.1 What does the gradient of this velocity-time graph represent? State also, without doing any calculations, the magnitude of the gradient. (3)
- 2.2 Determine the constant speed, v , with which the crate was being lifted before the cable snapped. (4)
- 2.3 Determine by using the graph, but **not** any equations of motion, the maximum height which the crate reaches above the position where the cable snapped. (4)
- 2.4 Show, **without using the time of fall**, that the magnitude of the velocity, v , with which the crate strikes the water, after the cable has snapped, is $24,58 \text{ m.s}^{-1}$. (3)

The crate, height 2 m, which is completely sealed so that no water can seep in, penetrates (sinks into) the water to a maximum depth of 1,5 m before rising again and coming to a stop.



2.5 Draw a labelled force diagram of the vertical forces acting on the crate when it is at its lowest point (maximum depth). The length of the respective vectors should indicate their relative magnitudes. (3)

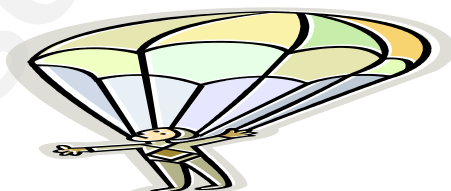
2.6 Determine the average acceleration of the crate from the moment it strikes the water until it reaches its maximum depth. (5)

2.7 Calculate the magnitude of the average force that the **water exerts on the crate** to bring it to a stop. (5)

[27]

QUESTION 3

Craig, who's mass is 80 kg, has gone parachuting. He aeroplaned to 10 000 feet (3 km) and jumped. However his parachute is stuck and he starts to panic.



3.1. If his parachute does not open, **use equations of motion** to calculate what velocity he will be travelling when he hits the ground. (Assume no air friction). (5)

(245m.s⁻¹)

3.2. Find his height above the ground after he has fallen for 5 seconds. (7)

(2857m)

[12]



QUESTION 4

A learner investigates the motion of a lift. He places his baby brother of 6 kg on a scale, in a lift. During the first 3 s of the motion, the scale reads 80 N, the scale reads 60 N for the next 5 s and for the last 2 s, it reads 30 N.



4.1 Calculate the magnitude and direction of the resultant force acting on the baby for all three parts of the journey. **(20N, 0N and 30N)**

(5)

4.2 Calculate the magnitude and direction of the acceleration for:

4.2.1 the first 3 s and **(3,33 m.s⁻²)**

4.2.2 the last 2 s of the journey, if the lift started from rest. **(5m.s⁻²)** (6)

4.3 Calculate the maximum velocity reached by the lift after the first 3 s of motion. **(10m.s⁻¹)** (4)

4.4 Calculate the final velocity reached at the end of the 10 s journey. **(0m.s⁻¹)** (4)

4.5 Using an **appropriate scale**, draw a velocity-time graph for the motion of the baby, for the entire 10s. (5)

[24

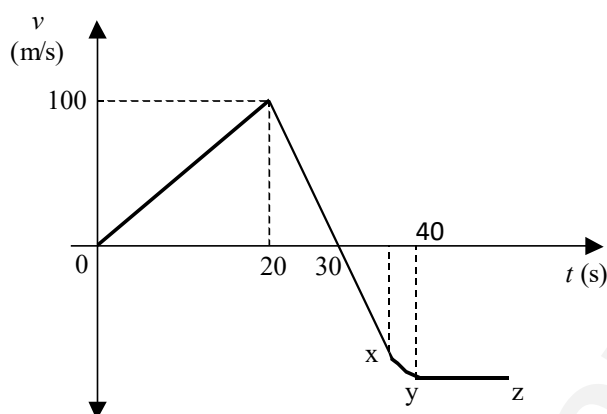
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QUESTION 5

The velocity-time graph below represents the motion of a toy rocket which accelerates from rest going vertically upwards away from the earth. After a certain time the engines are switched off.

Study the graph and then answer the questions that follow:





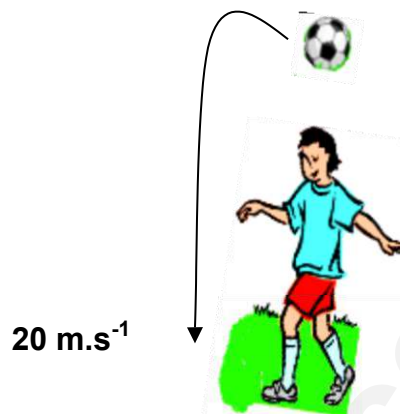
- 5.1 Using the graph or information from the graph, determine:
- 5.1.1 the maximum speed achieved by the rocket on its way up. **(100m.s⁻¹)** (1)
- 5.1.2 the magnitude of the acceleration of the rocket during the first 20 seconds of its motion. **(5m.s⁻¹)** (3)
- 5.1.3 the maximum height achieved by the rocket. **(1500m)** (3)
- 5.2 Explain what has happened to allow for the motion occurring from point **y** to point **z**. (3)
- 5.3 Draw an acceleration – time SKETCH graph for the motion from $t = 20\text{s}$ to $t = 40\text{s}$. Include all necessary values. (4)

14]



Question 6

A soccer player juggles a ball on his head by letting the ball bounce continuously on his head. After the last bounce the ball leaves his head it takes the ball 2,4 seconds to reach the ground



- 6.1 If the ball lands on the ground at 20m.s^{-1} determine the velocity with which the ball leaves the boys head. (**$3,52\text{ m.s}^{-1}$**) (5)
 - 6.2 Calculate the maximum height, above the boy's head reached by the ball. (**$0,63\text{ m}$**) (4)
 - 6.3 Sketch a velocity versus time graph representing the balls motion from the moment it leaves the boy's head until it lands on the ground. Indicate all relevant velocity and time values. (3)
- [12]**

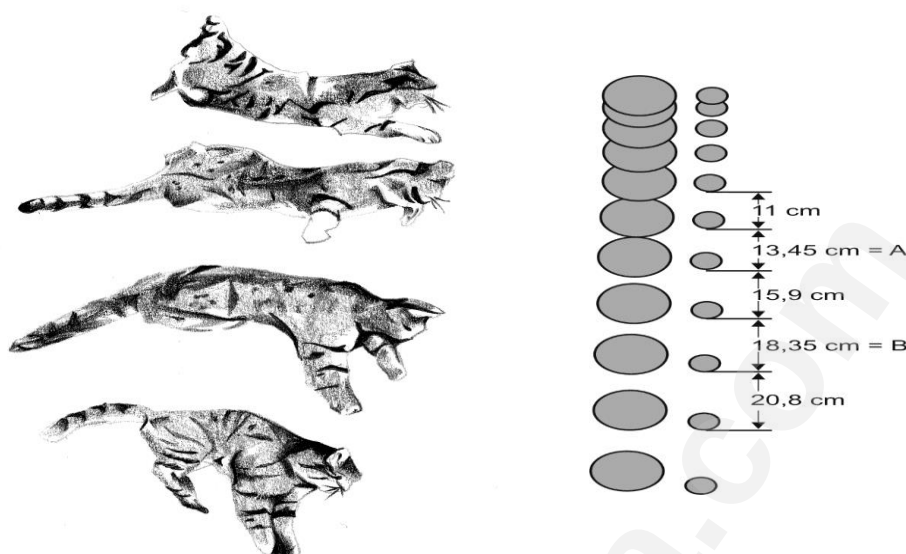
QUESTION 7

Measuring gravitational acceleration using multi-flash photography

Multi-flash photography is one of several methods that can be used to measure g . A photograph is taken of an object, falling freely in a darkened room. The object is illuminated at a certain frequency, resulting in different images of the same object at different positions during the fall. A multi-flash photograph of a falling cat is illustrated below.

One of the multi-flash photographs illustrated below, shows a small compact ball and a bigger styrofoam ball falling. The balls were illuminated at a **frequency of 20 Hz**. Using the relationship between frequency and period, the time elapsed between two images can be calculated as **0,05s**. The distances between a few successive images of the small ball were measured and are indicated (**not to scale**) on the photo.





- 7.1 Looking at the multi-flash photograph above, what evidence do we have that both the small compact ball and the bigger styrofoam ball accelerated? (1)
- 7.2 Both balls are expected to have the same acceleration due to gravity. Supply a possible explanation for the difference in acceleration of the two balls. (1)
- 7.3 Prove, using an appropriate calculation, that the time elapsed between two successive images during the fall, is 0,05s. **(0,05s)** (1)
- 7.4 Use the measurements (not according to scale) indicated on the photo and do the following calculations:
- (a) Calculate the average velocity of the ball for Interval A. **(2, 69m.s⁻¹)** (2)
- (b) Calculate the average velocity of the ball for Interval B. **(3, 67m.s⁻¹)** (2)
- (c) Use the calculated values for the average velocities in (a) and (b) and calculate the acceleration of the small compact ball. **(9,8 m.s⁻²)** (3)
- 7.5 Draw an acceleration-time graph to represent the motion of the compact ball. (2)

QUESTION 8

A hot-air balloon is rising upwards at a constant velocity of 5 m.s⁻¹. When the balloon is 100 m above the ground, a sandbag is dropped from it (see FIGURE 1). FIGURE 2 shows the path of the sandbag as it falls to the ground. Ignore air resistance.



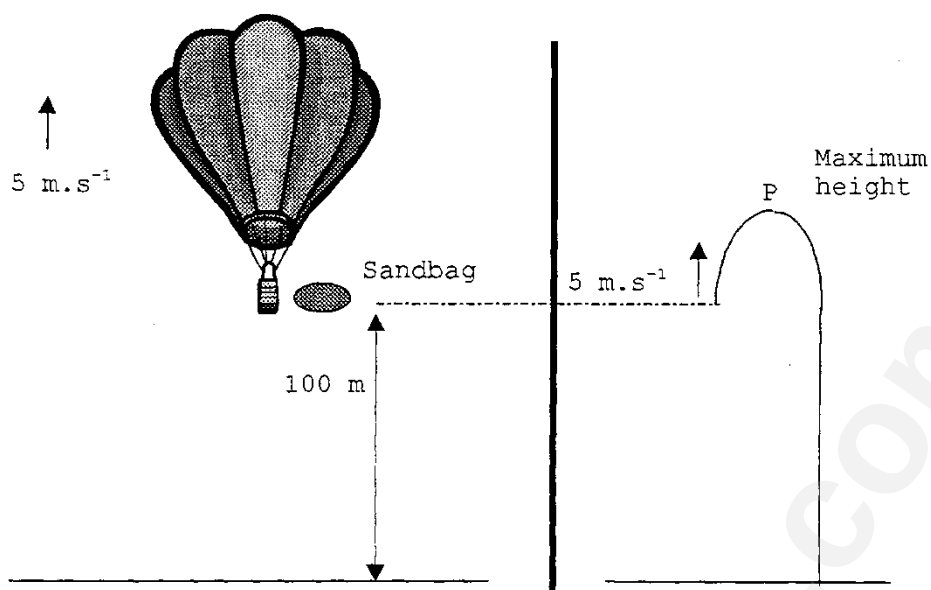


FIGURE 1

FIGURE 2 Motion of sandbag

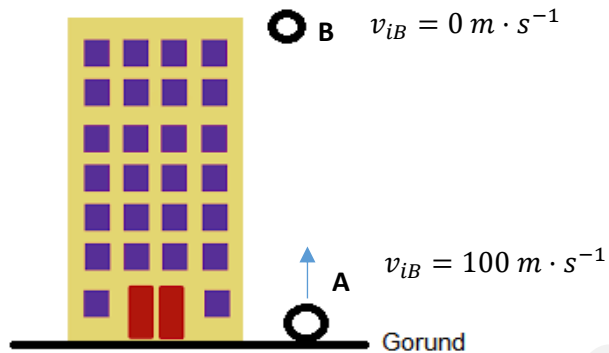
- 8.1 What is the magnitude of the acceleration of:
- 8.1.1 The hot-air balloon while the sandbag is in it? (2)
- 8.1.2 The sandbag the moment it is dropped from the hot-air balloon? (2)
- 8.2 Will the velocity of the hot-air balloon **INCREASE, DECREASE or REMAIN THE SAME** immediately after the sandbag has been released? Explain fully. (4)
- 8.3 Determine the maximum height P, above the ground, reached by the sandbag after it is released from the hot-air balloon. (4)
- 8.4 Calculate the time taken for the sandbag to reach this maximum height after it has been released. (4)
- 8.5 Calculate the total time taken for the sandbag to reach the ground after it has been released. (4)
- 8.6 Sketch a neat displacement versus time graph for the sandbag's motion from the moment it is dropped from the hot-air balloon until it hits the ground. Label all available numerical displacement and time values. (5)

[25]



Question 9

A very small rocket **A** is launched vertically upwards with an initial velocity of $100 \text{ m} \cdot \text{s}^{-1}$. At the same time a second stone **B** that is initially 150 m high is dropped from the top of very height building. Ignore air resistance.



- 9.1 Calculate the velocity of stone **B** when it hits the ground.
- 9.2 Calculate the time taken for **A** and **B** to pass each other.
- 9.3 Calculate the fly time of the small rocket **A**.
- 9.4 Draw the velocity versus time graph for the motion of the small rocket **A** from the moment it is launched until it strikes the ground. Indicate the respective values of the intercepts on your velocity-time graph.



SESSION 2: RATES OF REACTION AND CHEMICAL EQUILIBRIUM

Energy and change

Energy changes in reactions related to bond energy changes

- Define *heat of reaction* (ΔH) as the energy absorbed or released in a chemical reaction.
- Define *exothermic reactions* as reactions that release energy.
- Define *endothermic reactions* as reactions that absorb energy
- Classify (with reason) reactions as exothermic or endothermic.

Exothermic and endothermic reactions

- State that $\Delta H > 0$ for endothermic reactions, i.e. reactions in which energy is released.
- State that $\Delta H < 0$ for exothermic reactions, i.e. reactions in which energy is absorbed.

Activation energy

- Define *activation energy* as the minimum energy needed for a reaction to take place.
- Define an *activated complex* as the unstable transition state from reactants to products.
- Draw or interpret fully labelled sketch graphs (potential energy versus course of reaction graphs) of catalysed and uncatalysed endothermic and exothermic reactions.

Rate and Extent of Reactions

Rates of reactions and factors affecting rate

- Define *reaction rate* as the change in concentration of reactants or products per unit time.
- Calculate reaction rate from given data.

$$\text{Rate} = \frac{\Delta c}{\Delta t} \text{ (Unit: } \text{mol} \cdot \text{dm}^{-3} \cdot \text{s}^{-1} \text{)}$$

Questions may also include calculations of rate in terms of change in mass/volume/ number of moles per time.

- List the factors that affect the rate of chemical reactions, i.e. nature of reacting substances, surface area, concentration (pressure for gases), temperature and the presence of a catalyst.
- Explain in terms of the collision theory how the various factors affect the rate of chemical reactions. The collision theory is a model that



explains reaction rate as the result of particles colliding with a certain minimum energy.

Measuring rates of reaction

- Answer questions and interpret data (tables or graphs) on different experimental techniques for measuring the rate of a given reaction.

Mechanism of reaction and of catalysis

- Define the term *positive catalyst* as a substance that increases the rate of a chemical reaction without itself undergoing a permanent change.
- Interpret graphs of distribution of molecular energies (number of particles against their kinetic energy or Maxwell-Boltzmann curves) to explain how a catalyst, temperature and concentration affect rate.
- Explain that a catalyst increases the rate of a reaction by providing an alternative path of lower activation energy. It therefore decreases the net/total activation energy.

LEARNING OBJECTIVES

Rate and extent of chemical reactions

- Define the following terms:
 - Heat of reaction ΔH
 - Endothermic reaction
 - Activated complex
 - Positive catalyst
 - Exothermic reaction
 - Activation energy
 - Reaction rate
- Draw or interpret fully labelled sketch graphs of potential energy versus course of reaction graphs. With and without a catalyst.
- List the factors which affect the rate of chemical reactions:
 - Surface area (solid)
 - Concentration (solution), pressure (gas)
 - Temperature
 - Addition of catalyst
 - Nature of reacting substances
- Use the collision theory to explain how the various factors affect the rate of



chemical reactions

- Calculate reaction rate from given data and using graphs.
 - Use the formula: $\text{Rate} = \frac{\Delta c}{\Delta t}$ or $\text{Rate} = \frac{\Delta V}{\Delta t}$
- Maxwell-Boltzmann curves:
 - Interpret graphs of distribution of molecular energies (number of particles against their kinetic energy or) to explain how a catalyst, temperature and concentration affect rate.
- Draw and interpret graphs of distribution of molecular energies (number of particles against their kinetic energy

RATES OF REACTIONS

MCQ

- 1.1 Which ONE of the following describes the effect of a positive catalyst on the net activation energy and the heat of reaction (ΔH) of a specific reaction?

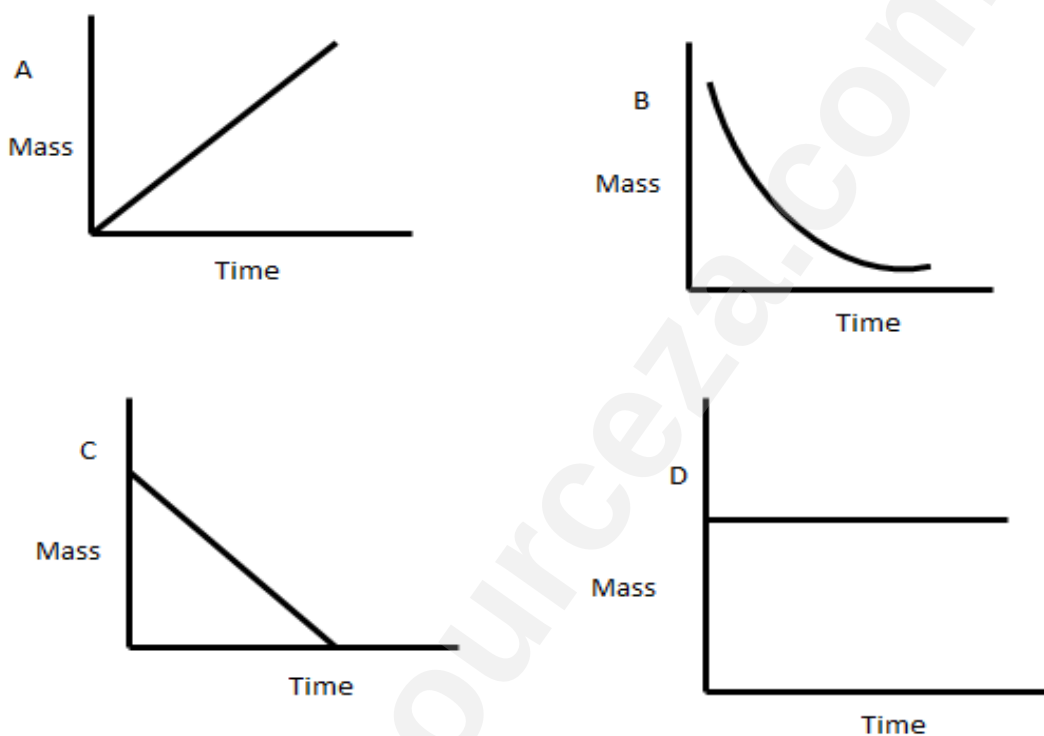
	NET ACTIVATION ENERGY	ΔH
A	increase	no effect
B	Decrease	Increase
C	No effect	Decrease
D	Decrease	No effect

- 1.2 The activation energy for a certain reaction is $50 \text{ kJ} \cdot \text{mol}^{-1}$. Energy is absorbed when this reaction takes place. Which ONE of the following is correct for the reverse reaction?

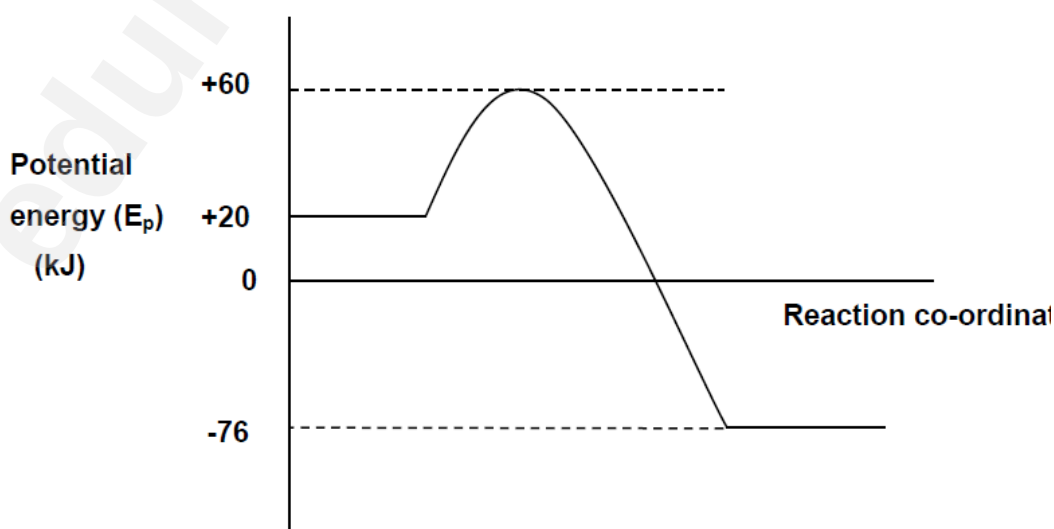
	Activation Energy (E_A)	Heat of Reaction (ΔH)
A	$E_A > 50 \text{ kJ} \cdot \text{mol}^{-1}$	$\Delta H > 0$
B	$E_A > 50 \text{ kJ} \cdot \text{mol}^{-1}$	$\Delta H < 0$
C	$E_A < 50 \text{ kJ} \cdot \text{mol}^{-1}$	$\Delta H < 0$
D	$E_A < 50 \text{ kJ} \cdot \text{mol}^{-1}$	$\Delta H > 0$



- 1.3 Which ONE of the following graphs shows the mass of a catalyst against time at the end of the chemical reaction?



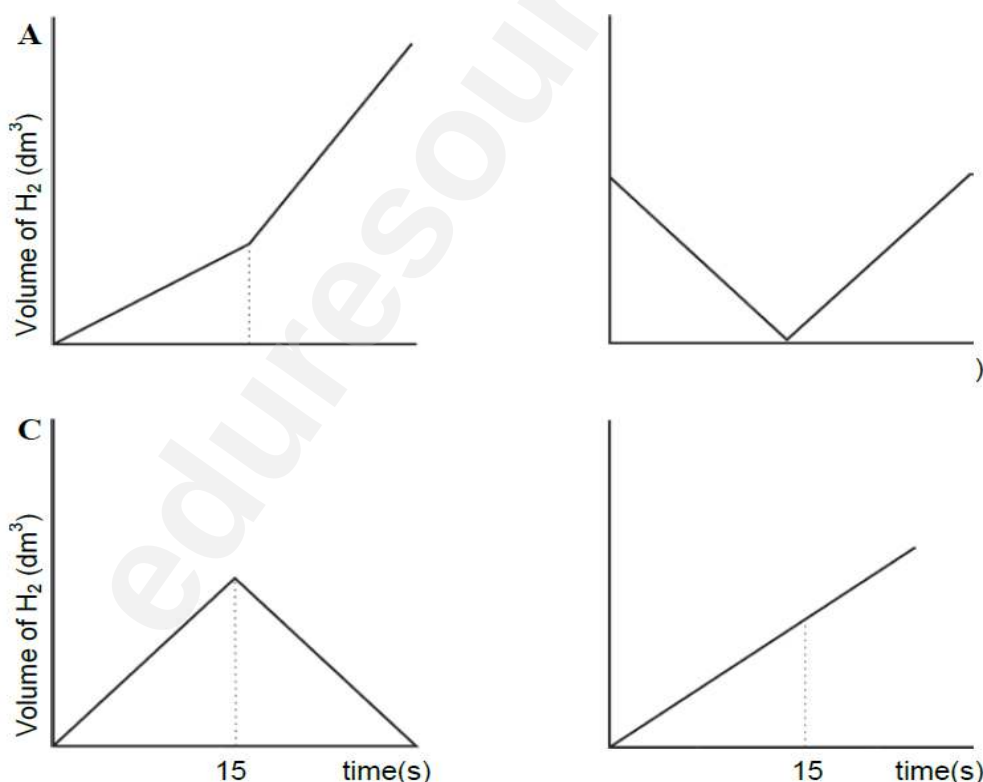
- 1.4 Consider the following energy profile:



According to this profile, what would be the Activation Energy and Heat of Reaction for the **reverse reaction**?

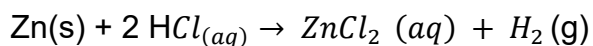
	Activation Energy (kJ)	Heat of Reaction (kJ)
A	-20	+96
B	+40	+96
C	-136	-96
D	+136	+96

- 1.5 When zinc reacts with dilute hydrochloric acid, hydrogen gas is produced as one of the products. The volume of hydrogen gas evolved is measured every second. Shortly after the reaction started, a catalyst is added to the reaction. Which one of the following graphs is an accurate representation of the course of the reaction?

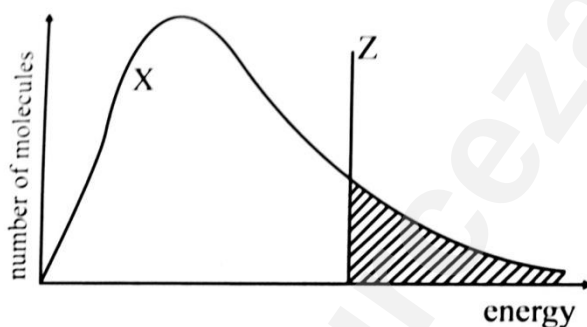


QUESTION 2

- 2.1 A learner investigates a way to increase the rate at which hydrogen gas develops in the reaction between zinc and hydrochloric acid. The reaction takes place as shown below.



A learner obtained the following Maxwell- Boltzmann distribution curve:



Curve X shows the initial condition.

- | | | |
|-------|--|---|
| 2.1.1 | Why does the curve go through the origin of the graph? | 2 |
| 2.1.2 | Why does the curve not touch the X-axis at the high-energy side? | 1 |
| 2.1.3 | What does the shaded part of the graph represent? | 1 |
| 2.1.4 | What does line Z represents | 1 |

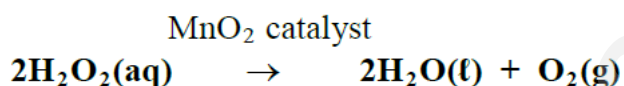
Redraw the graph in your answer sheet, mark the original curve X and line Z

clearly and then indicate clearly how curve X and/ or line Z will change if the learner :

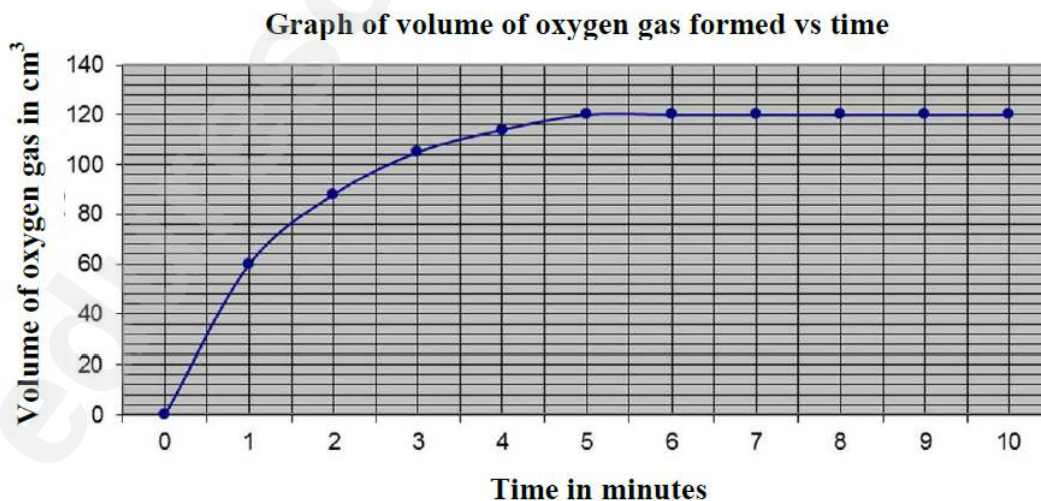
- | | | |
|-------|---|---|
| 2.1.5 | Increases the temperature of the $\text{HCl}_{(\text{aq})}$ solution. | 2 |
|-------|---|---|
- (Mark this curve line with A)



- 2.1.6 Increases the concentration of the $\text{HCl}_{(aq)}$ solution. 2
(Mark this curve/line with B)
- 2.1.7 Adds a suitable catalyst (Mark this curve/line with C) 2
- 2.1.8 Apply the collision theory and explain why an increase in the temperature of the $\text{HCl}_{(aq)}$ solution results in a higher reaction rate. 3
- 2.2 Manganese dioxide (MnO_2) catalyses the decomposition of a hydrogen peroxide solution (H_2O_2 (aq)) into water and oxygen.



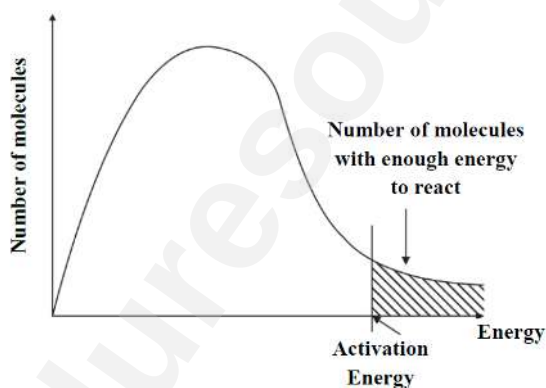
0,1 g of manganese dioxide (MnO_2) was added to 200 cm^3 of a $0,2 \text{ mol} \cdot \text{dm}^{-3}$ solution of hydrogen peroxide (H_2O_2 (aq)). The oxygen gas produced was collected at standard temperature and pressure and measured every minute using a gas syringe. The readings were plotted to give the following graph:



Use the graph to answer the following questions.

- | | | |
|-------|--|---|
| 2.2.1 | Define the term reaction rate | 2 |
| 2.2.2 | Explain why the gradient of the graph decreases as the reaction proceeds. | 2 |
| 2.2.3 | The reaction stops before reaching completion.
Write down the time at which the reaction stopped. | 1 |
| 2.2.4 | Define the term positive catalyst. | 2 |
| 2.2.5 | How much of the catalyst manganese dioxide, MnO_2 , remains at the end of the reaction? | 2 |
| 2.2.6 | Calculate the concentration of the hydrogen peroxide after the reaction has stopped. | 6 |

The Maxwell-Boltzmann distribution curve below shows the decomposition of the H_2O_2 without using a catalyst.



- | | | |
|-------|---|---|
| 2.2.7 | Explain in terms of the collision theory how the MnO_2 catalyst increases the rate of decomposition of the H_2O_2 . | 4 |
| 2.2.8 | Redraw the graph in your book and show how the activation energy changes when the decomposition reaction is carried out with the MnO_2 catalyst. | 2 |

QUESTION 3

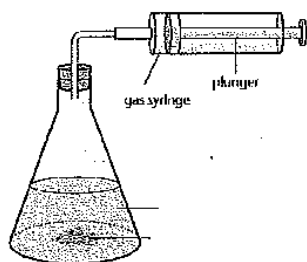


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3. At room temperature and pressure a flask was connected to a gas syringe. 60 cm^3 of 0.05 mol.dm^{-3} dilute hydrochloric acid (HCl) was placed in the flask. 2g (an excess) of granules of a reactive metal were added, the flask was quickly stoppered and the readings of the volume of gas in the syringe were recorded at half minute time intervals.

The diagram and the results of the experiment are shown below:



Time (minutes)	Volume of gas (cm^3)
0	0
0.5	5
1	18
1.5	24
2	28
2.5	31
3	33
3.5	34
4	35
4.5	35.5
5	36
5.5	36

- 3.1 A colourless gas is produced in the reaction. 2
What is the name AND formula of the gas?
- 3.2 Plot and draw a graph that represents the gas produced against time. 6
- 3.3 Use your to graph to determine how long it took for 29 cm^3 of gas to be produced?
- 3.4.1 Write down the volumes of gas produced at the following times:
 $t = 1 \text{ minute}$
 $t = 2 \text{ minutes}$
 $t = 3 \text{ minutes}$

3.4.2 Explain the trend observed in question 3.4.1, refer to RATE OF GAS PRODUCED and the REACTION RATE

2



- 3.4.3 Use the collision theory to explain the differences in the rate of production of gas at these times. 4

The experiment was repeated using larger pieces (chunks) of excess metal, under the same conditions.

- 3.5 On the same set of axis of question 3.2 above sketch the graph that will represent the results obtained when the chunks of excess metal is used. 3
Label this A.

- 3.6 Give reasons for your choice of sketch labelled A. 3

The experiment was repeated , but this time **only** the temperature was increased. (The larger granules **WERE NOT** used.)

- 3.7 On the same set of axis of question 3.2 above sketch the graph that will represent the results obtained when the temperature is increased. 3
Label this B.



SESSIN 3 : CHEMICAL EQUILIBRIUM

Chemical Equilibrium

Chemical equilibrium and factors affecting equilibrium

- Explain what is meant by:
 - Open and closed systems: An open system continuously interacts with its environment, while a closed system is isolated from its surroundings.
 - A reversible reaction: A reaction is reversible when products can be converted back to reactants.
 - Chemical equilibrium: It is a dynamic equilibrium when the rate of the forward reaction equals the rate of the reverse reaction.
- List the factors that influence the position of an equilibrium, i.e. pressure (gases only), concentration and temperature.

Equilibrium constant

- List the factors that influence the value of the equilibrium constant, K_c .
- Write down an expression for the equilibrium constant having been given the equation for the reaction.
- Perform calculations based on K_c values.
- Explain the significance of high and low values of the equilibrium constant.

Application of equilibrium principles

- State Le Chatelier's principle: When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will oppose the disturbance.
- Use Le Chatelier's principle to explain changes in equilibria qualitatively.
- Interpret graphs of equilibrium, e.g. concentration/rate/number of moles/mass/volume versus time graphs.
- Explain the use of rate and equilibrium principles in the Haber process and the contact process.

LEARNING OBJECTIVES

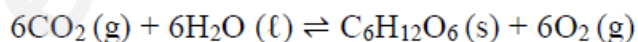
- The following definitions and explanations must be known.
 - Definition of chemical equilibrium.
 - Reversible reaction.
 - Open and closed systems.
 - State Le Chateliers principle
 - Catalyst
- Use Le Chateliers' principle to explain how the following changes effect the positon of the equilibrium:



- temperature,
- concentration
- pressure (only in the case of gases.)
- Remember the following:
 - A catalyst will increase the rate of both the forward and reverse reaction. Equilibrium will be reached quicker. The catalyst has no effect on the concentrations at equilibrium.
 - ΔH is quoted for the forward reaction.
- Equilibrium graphs.
 - Rate of reaction vs time.
 - Concentration/rate/number of moles/mass/volume versus time graphs.
- K_c values
 - $K_c > 1$ or higher K_c values indicate that the forward reaction is favoured.
 - $K_c < 1$ or lower K_c values indicate that the reverse reaction is favoured.
- K_c calculations
 - If the K_c value is supplied then in all likelihood you will need to perform a calculation.
 - It is not always necessary to draw a table.

CHEMICAL EQUILIBRIUM - MCQ

- 1.1 The reaction represented by the balanced equation below reaches equilibrium in a closed container:



Which ONE of the following is the correct K_c expression for the reaction?

A

$$K_c = \frac{[\text{O}_2]^6}{[\text{CO}_2]^6}$$



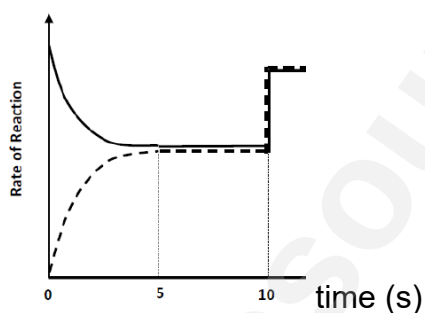
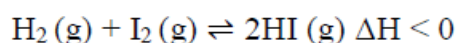
B
$$K_c = \frac{[C_6H_{12}O_6][O_2]^6}{[CO_2]^6[H_2O]^6}$$

C
$$K_c = \frac{[CO_2]^6[H_2O]^6}{[C_6H_{12}O_6][O_2]^6}$$

D
$$K_c = \frac{[CO_2]^6}{[O_2]^6}$$

- 1.2 The graphs represent the change in the rate of reaction versus time for the reversible reaction that took place when an amount of hydrogen (H₂) gas and iodine (I₂) gas was sealed in a container.

The equation for the reaction is:



Which ONE of the following BEST explains the change that occurred at **t = 5s** and **t = 10s**?

	t = 5 s	t = 10s
A	The reaction has stopped	Concentration was increased
B	Equilibrium established	A catalyst was added
C	The reaction has stopped	A catalyst was added
D	Equilibrium established	Temperature has been increased

- 1.3 A weak acid HA dissociates in aqueous solution as shown below





Which **ONE** of the following changes will result in an **increase** in the $[\text{H}^+]$ of the solution?

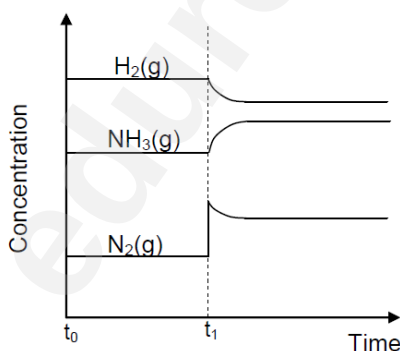
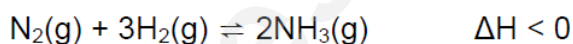
- A Addition of a little aqueous sodium hydroxide solution
- B Raising the temperature of the solution
- C Dissolving a little of the sodium salt, NaA, in the solution
- D Adding a catalyst to the solution

- 1.4 In the following reaction below $K_c = 0.1$. What is the K_c value for the **reverse reaction**?



- A 0.1
- B 1
- C 0.01
- D 10

- 1.5 The graph below shows a change made to a chemical equilibrium in a closed container at time t_1 . The equation for the reaction is:



Which **ONE** of the following is the change made at time t_1 ?

- A Addition of a catalyst
- B Increase in temperature



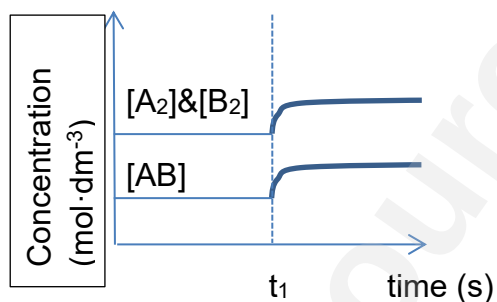
- C Increase in the concentration of $\text{N}_2(\text{g})$
 D Increase in the concentration of N_2 and NH_3 .

1.6 In the hypothetical reaction below A_2 and B_2 reach equilibrium according to the reaction below:



A change was made at time t_1 .

The graphs below shows the changes in concentrations of the reactants and products as a result of this change.



Which ONE of following changes was made?

- A Volume was decreased
 B Volume was increased
 C Reactants and products were increased
 D A catalyst was added



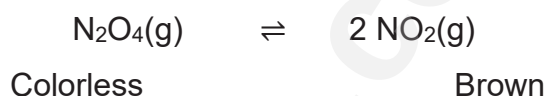
LONG QUESTIONS

QUESTION 2

2.1 The reaction below reaches equilibrium in a **closed system** at 25°C.

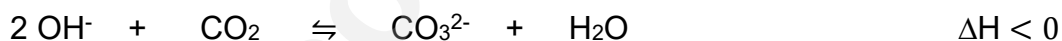
$$K_c = 1 \times 10^3 \quad \text{at } 500\text{K}$$

$$K_c = 1 \times 10^4 \quad \text{at } 600\text{K}$$



- 2.1.1 Explain what is meant by a closed system. 2
- 2.1.2 Is the forward reaction EXOTHERMIC or ENDOTHERMIC? 1
- 2.1.3 Using Le Chateliers principle explain the colour that will be observed when the temperature is decreased to 400 K. 4

2.2 The following equilibrium exists at a certain temperature and pressure:



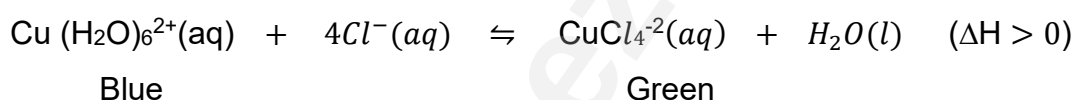
Some changes are made to the conditions as shown in the given table below. Complete the table to show how the equilibrium will be affected by the changes.

(Write only: **Decreases; Increases or No change**)



CHANGE	Rate of forward reaction	Concentration of CO_3^{2-}	K_c value
Increase in temperature	A	B	C
Addition of drops of concentrated NaOH (aq)	D	E	F
Addition of a catalyst	G	H	I

2.3 Hydrated copper ions, $\text{Cu}(\text{H}_2\text{O})_6^{2+}$ are responsible for **blue** colour of dilute aqueous solution of copper (II) chloride. If concentrated Hydrochloric acid is added to the solution, it becomes **green** because of the formation of CuCl_4^{2-} according to the given reversible reaction.

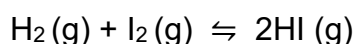


What effect will the following changes have on the solution? Choose the answer from BECOMES BLUE; BECOMES GREEN or NO CHANGE and then use Le Chateliers principle to explain your answer.

- 2.3.1 Water is added to green solution. 4
- 2.3.2 The blue solution is cooled. 4
- 2.3.3 Crystals of table salt are added to the blue solution. 4

QUESTION THREE

3.1 Consider the given equilibrium reaction below:



A mixture of 0.5 moles of $\text{H}_2(\text{g})$ and 0.5 moles of $\text{I}_2(\text{g})$ are allowed to react in a 2 dm^3 container. The equilibrium constant for this reaction at 448°C is 49.

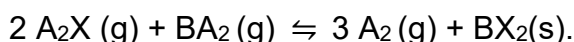


3.1.1 Calculate the concentration of $I_2(g)$ at equilibrium.

11

3.2 1 mol of $A_2X(g)$ is added to 1mol of $BA_2(g)$ in an empty container of volume 2000 cm^3 . When the reaction reaches equilibrium at 500K , it is found that, there are 0.4 mol of $BX_2(s)$ in the container.

The forward reaction is exothermic. The reaction is given below.



3.2.1 Calculate the value of the equilibrium constant at 500K .

3.3 The following reaction reaches equilibrium in a closed container at certain temperature.



At equilibrium it is found that the:

$$[SO_3] = 0.04\text{ mol}\cdot\text{dm}^{-3}$$

$$[SO_2] = 0.5\text{ mol}\cdot\text{dm}^{-3}$$

$$\text{mass of Oxygen} = 19.2\text{g},$$

$$K_c \text{ value} = 31.25$$

3.3.1 Calculate the volume of the container.

3.4 On heating sodium hydrogen carbonate, $NaHCO_3$, it breaks up according to the following balanced equation:



Sodium bicarbonate is usually added to food during baking. The carbon dioxide gas produced during baking causes the cake to rise.

If 0.012 moles of $NaHCO_3$ are totally decomposed and the K_c value at



equilibrium is found to be 2.4.

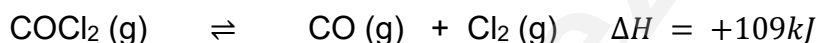
Calculate:

3.4.1 The volume of the container. (6)

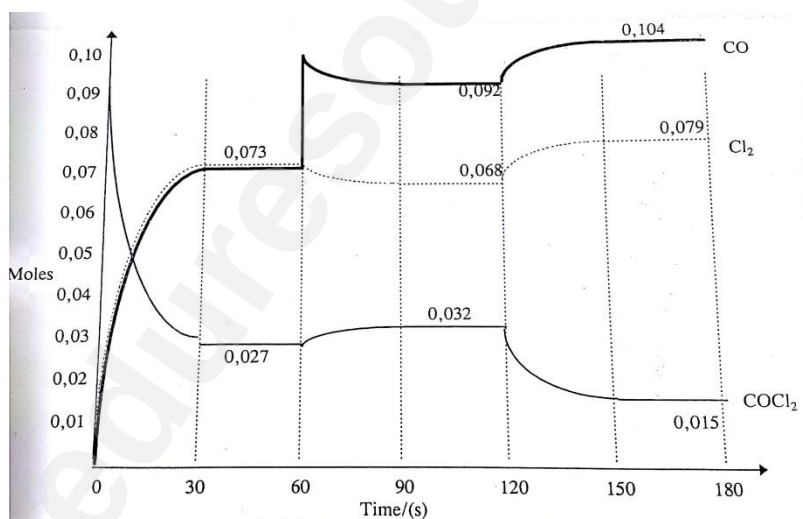
3.4.2 Expected yield of Sodium carbonate (NaCO_3) in grams. (3)

QUESTION 4

4.1 0.1 mole COCl_2 (g) is placed in a gas syringe. When equilibrium was established for the first time the volume of the gas recorded was 1 dm^3 of COCl_2 (g) decomposes according to the following chemical equation.



Study the equation given above, and the graph below, and answer the questions that follow.



4.1 How much time was required for the system to come to equilibrium for the first time? 1

How do the rates of the forward reaction **and** reverse reaction compare at the following times? Write only GREATER THAN, EQUAL TO OR LESS THAN.



- | | | |
|-----|---------------------|---|
| 4.2 | $t = 15 \text{ s}$ | 1 |
| 4.3 | $t = 45 \text{ s}$ | 1 |
| 4.4 | $t = 105 \text{ s}$ | 1 |

Use the graph to explain what happened between the following times and then use Le Chateliers principle to give a reason for your answer :

- | | | |
|-----|---|---|
| 4.5 | $t = 60 \text{ s}$ and 90 s . | 5 |
| 4.6 | $t = 120 \text{ s}$ and 150 s . | 5 |
| 4.7 | Use the graph to calculate the equilibrium constant K_c for the reaction at $t = 90 \text{ s}$. | 4 |
| 4.8 | Determine the K_c value at $t = 180 \text{ s}$ | 2 |
| 4.9 | Compare the K_c values in 4.7 and 4.8. Write only HIGHER THAN, LOWER THAN or EQUAL TO. Explain your answer. | 2 |



SESSION NO: 4

TOPIC: NEWTONS LAWS; WORK, ENERGY AND POWER

NOTE: It becomes easier to combine revision of Newton 2 with work ,energy and power

Newton's laws and application of Newton's laws

Different kinds of forces: weight, normal force, frictional force, applied force (push, pull), tension (strings or cables)

- ☛ Define *normal force*, N , as the force or the component of a force which a surface exerts on an object with which it is in contact, and which is perpendicular to the surface.
- ☛ Define *frictional force*, f , as the force that opposes the motion of an object and which acts parallel to the surface.
- ☛ Define *static frictional force*, f_s , as the force that opposes the tendency of motion of a stationary object relative to a surface.
- ☛ Define *kinetic frictional force*, f_k , as the force that opposes the motion of a moving object relative to a surface.

Know that a frictional force:

- ♦ Is proportional to the normal force
- ♦ Is independent of the area of contact
- ♦ Is independent of the velocity of motion
- ☛ Solve problems using $f_s^{max} = \mu_s N$ where f_s^{max} is the maximum static frictional force and μ_s is the coefficient of static friction.

NOTE:

- ♦ If a force, F , applied to a body parallel to the surface does not cause the object to move, F is equal in magnitude to the static frictional force.
- ♦ The static frictional force is a maximum (f_s^{max}) just before the object starts to move across the surface.
- ♦ If the applied force exceeds f_s^{max} , a resultant (net) force accelerates the object.



- ☛ Solve problems using $f_k = \mu_k N$, where f_k is the kinetic frictional force and μ_k the coefficient of kinetic friction.

Force diagrams, free-body diagrams

- ☛ Draw force diagrams.
- ☛ Draw free-body diagrams. (This is a diagram that shows the relative magnitudes and directions of forces acting on a body/particle that has been isolated from its surroundings)
- ☛ Resolve a two-dimensional force (such as the weight of an object on an inclined plane) into its parallel (x) and perpendicular (y) components.
- ☛ Determine the resultant/net force of two or more forces.

Newton's first, second and third laws of motion

- ☛ State Newton's first law of motion: A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it.
- ☛ Discuss why it is important to wear seatbelts using Newton's first law of motion.
- ☛ State Newton's second law of motion: When a resultant/net force acts on an object, the object will accelerate in the direction of the force at acceleration directly proportional to the force and inversely proportional to the mass of the object.
- ☛ Draw force diagrams and free-body diagrams for objects that are in equilibrium or accelerating.
- ☛ Apply Newton's laws of motion to a variety of equilibrium and non-equilibrium problems including:
 - ◆ A single object:
 - Moving on a horizontal plane with or without friction
 - Moving on an inclined plane with or without friction
 - Moving in the vertical plane (lifts, rockets, etc.)
 - ◆ Two-body systems (joined by a light inextensible string):
 - Both on a flat horizontal plane with or without friction
 - One on a horizontal plane with or without friction, and a second hanging vertically from a string over a frictionless pulley

Both on an inclined plane with or without friction



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➤ Both hanging vertically from a string over a frictionless pulley

- ☛ State Newton's third law of motion: When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body.
- ☛ Identify action-reaction pairs.
- ☛ List the properties of action-reaction pairs.

Newton's Law of Universal Gravitation

- ☛ State Newton's Law of Universal Gravitation: Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.
- ☛ Solve problems using: $F = \frac{Gm_1m_2}{r^2}$
- ☛ Calculate acceleration due to gravity on a planet using: $g = \frac{Gm}{r^2}$
- ☛ Describe *weight* as the gravitational force the Earth exerts on any object on or near its surface.
- ☛ Calculate weight using the expression $w = mg$.
- ☛ Calculate the weight of an object on other planets with different values of gravitational acceleration.
- ☛ Distinguish between *mass* and *weight*.
- ☛ Explain *weightlessness*.

NEWTONS 2 LAWS

Definitions and laws

Normal force

Frictional force

State Newton's second law

Diagrams

Force and free body diagrams:

- (i) Resolve two-dimensional forces (such as the weight of an object with respect to the inclined plane) into its parallel (x) and perpendicular (y) components



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- (ii) Draw force diagrams and free-body diagrams for objects that are in equilibrium or accelerating

Calculations of Newton 2

Note: revise calculations of net force then continue to calculations of W_{net}

Apply Newton's 2 laws to a variety of equilibrium and non-equilibrium problems including:

A single object moving :

- on a horizontal plane with or without friction
- on an inclined plane with and without friction
- in the vertical plane (lifts, rockets, etc.)
-

Two-body systems (joined by a light inextensible string):

- Both on a flat horizontal plane with and without friction
- One on a horizontal plane with and without friction, and a second hanging vertically from a string over a frictionless pulley
- Both on an inclined plane with or without friction
- Both hanging vertically from a string over a frictionless pulley

WORK AND ENERGY

Work, Energy and Power

Work

- Define the work done on a constant force F as $F\Delta x \cos\theta$, where F is the magnitude of the force, Δx the magnitude of the displacement and θ the angle between the force and the displacement. (Work is done by a force on an object – the use of 'work is done against a force', e.g. work done against friction, should be avoided.)
 - Draw a force diagram and free-body diagrams.
 - Calculate the net/total work done on an object.
 - Distinguish between *positive net/total work done* and *negative net/total work done* on the system.

Work-energy theorem

- State the work-energy theorem: The net/total work done on an object is equal to the change in the object's kinetic energy OR the work done on an object by a resultant/net force is equal to the change in the object's kinetic energy.

In symbols: $W_{net} = \Delta K = K_f - K_i$

- Apply the work-energy theorem to objects on horizontal, vertical and inclined planes (for both frictionless and rough surfaces).



Conservation of energy with non-conservative forces present

- Define a *conservative force* as a force for which the work done in moving an object between two points is independent of the path taken. Examples are gravitational force, the elastic force in a spring and electrostatic forces (coulomb forces).
- Define a *non-conservative force* as a force for which the work done in moving an object between two points depends on the path taken. Examples are frictional force, air resistance, tension in a chord, etc.
- State the principle of conservation of mechanical energy: The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. (A system is isolated when the resultant/net external force acting on the system is zero.)
- Solve conservation of energy problems using the equation:

$$W_{nc} = \Delta E_k + \Delta E_p$$
- Use the relationship above to show that in the absence of non-conservative forces, mechanical energy is conserved.

Power

- Define *power* as the rate at which work is done or energy is expended.

In symbols: $P = \frac{W}{\Delta t}$

- Calculate the power involved when work is done.
- Perform calculations using $P_{ave} = Fv_{ave}$ when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane.
- Calculate the power output for a pump lifting a mass (e.g. lifting water through a height at constant speed).

Definitions

- Define the work done on an object
- State the work-energy theorem
- Define a conservative force: Know examples of conservative forces
- Define a non-conservative force: Know examples of non-conservative forces
- State the principle of conservation of mechanical energy

Diagrams

- Draw a force diagram and free-body diagrams.

Calculations



- Calculate the net work done on an object using $W_{net} = \Delta E_K = E_{Kf} - E_{Ki}$
- Distinguish between positive net work done and negative net work done on the system.
- Apply the work-energy theorem to objects on horizontal, vertical and inclined planes (for both frictionless and rough surfaces).
 - Solve conservation of energy problems using the equation : $W_{nc} = \Delta E_k + \Delta E_p$

Power

Definitions

- Define power

Calculations

- Calculate the power involved when work is done :

$$P = \frac{W}{\Delta t}$$

- Perform calculations using $P_{ave} = Fv_{ave}$ when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane.
- Calculate the power output for a pump lifting a mass (e.g. lifting water through a height at constant speed).

NEWTONS SECOND LAWS

Question 1

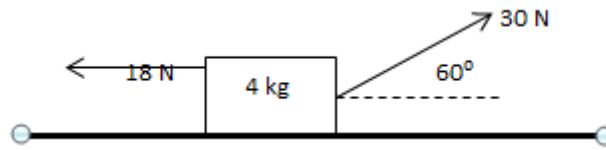
Multiple choice questions

1.1 A mass of 2 kg is suspended from a spring scale. Under what circumstances will the reading on the scale be less than 20 N ? When the scale is being

- A accelerated upwards
- B accelerated downwards
- C moved downwards at constant velocity
- D moved upwards at constant velocity.

1.2 A block of mass 4 kg is at rest on a smooth horizontal surface as shown in the diagram. The two forces in the diagram are applied simultaneously to the block.





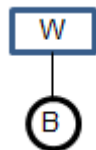
1.1 What will happen to the block? The block will...

- A remain stationary
- B accelerate to the right.
- C accelerate to the left.
- D be lifted off the surface

1.2 The resultant of two forces acting at a point on a body

- A is in the same direction as the larger of the two forces
- B produces the same effect as the two forces together
- C keeps the body in equilibrium
- D results in the body moving with constant velocity

1.3 A heavy steel ball B hangs on a rope which is tied to a block W. This whole system falls freely through the air. Ignore friction.

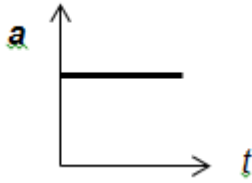


The tension in the rope is...

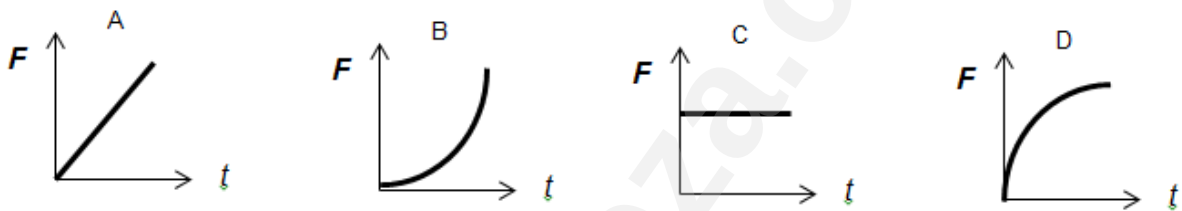
- A the difference between the masses of B and W
- B the difference between the weights of B and W
- C the sum of the weights of B and W
- D zero.



1.4. The acceleration-time graph for the motion of a certain body is shown in the graph below :

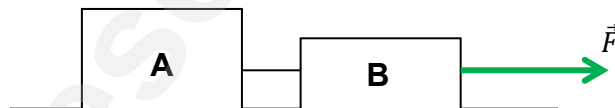


Which of the following graphs best illustrates the corresponding graph of the resultant force on the body versus time?



Question 2

Two blocks of the same materials are connected by a light, inelastic rope. Block A has a mass of 5 kg, and block B a mass of 3 kg. Another rope is fixed to block B and a force, $\vec{F}$, of 100N is applied horizontally. The blocks are moving along a horizontal frictionless surface.



2.1 Draw separated labelled free-body diagrams of all the forces action on the blocks.

2.2 Calculate the acceleration of the blocks.

2.3 Calculate the magnitude of the tension in the string.

The two blocks are now pulled over another surface and the blocks experience friction. The blocks accelerate at $8,972 \text{ m} \cdot \text{s}^{-2}$. The force exerted by the rope on block A is 62,5 N.

2.4 Calculate the kinetic coefficient of friction for block A.

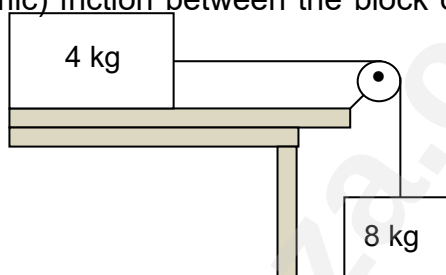
2.5 If the two blocks have the same surface area, block B will have different coefficient of friction? Explain your answer.



- 2.6 Calculate the frictional force exerted by the surface on block B.
- 2.7 Name two action-reaction pair in the system.

Question 3

A 4 kg block on a horizontal, rough surface is connected to a 8 kg block by a light inextensible string that passes over a frictionless pulley as shown below. The coefficient of kinetic (dynamic) friction between the block of 4 kg and the surface is 0,6.



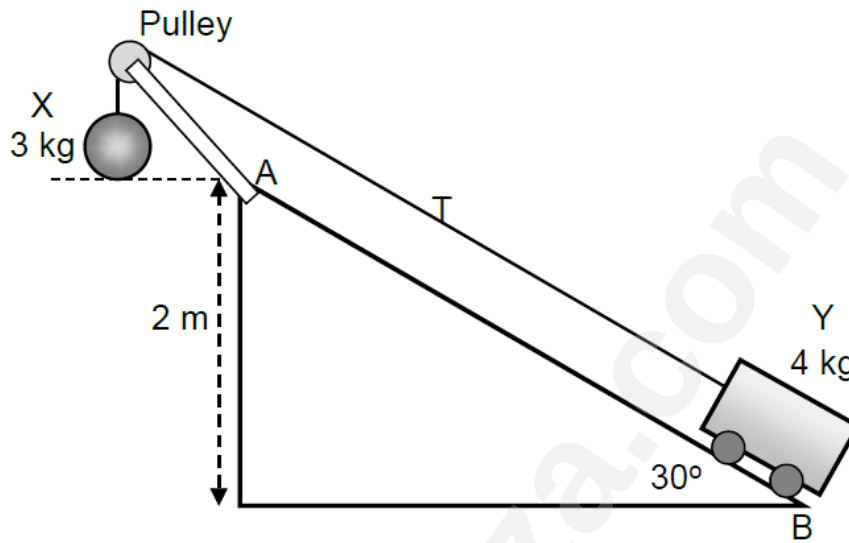
- 3.1. Draw a free-body diagram of all the forces acting on both blocks.
- 3.2. Write down Newton's second law of motion in words.
- 3.3. Calculate the acceleration of the system.
- 3.4. Calculate the magnitude of the tension in the string.
- 3.5. Calculate the magnitude of the frictional force that acts on the 4 kg block.
- 3.6. Calculate the apparent weight of the 8 kg block.
- 3.7. How does the apparent weight of the 8 kg block compare with its true weight?
Write down only, GREATER THAN, EQUAL TO or LESS THAN.
- 3.8. How does the apparent weight of the 4 kg block compare with its true weight?
Write down only, GREATER THAN, EQUAL TO or LESS THAN.

QUESTION 4

Ball X of mass 3 kg is attached to trolley Y of mass 4 kg by a light string which passes over a frictionless pulley as shown in the diagram. Initially the trolley is at rest on a slope AB, which makes an angle of 30° with the horizontal. When the ball is released it falls to the ground and the trolley moves 2 m up the slope accelerating at $0,43 \text{ m.s}^{-2}$.

The coefficient of kinetic friction along slope AB is $\mu_k = 0,2$. (Ignore the rotation effects of the wheels and air friction.)





4.1 Draw a labelled free body diagram to show ALL the forces acting on the trolley as it moves up the slope. (4)

4.2 Show that a friction force of 6,79 N acts on the trolley as it moves up the slope.

4.3 State Newton's Second Law of motion in words. (2)

4.5 Calculate the tension T in the string. (5)

4.6 Calculate the speed with which the 3 kg ball strikes the ground. (4)

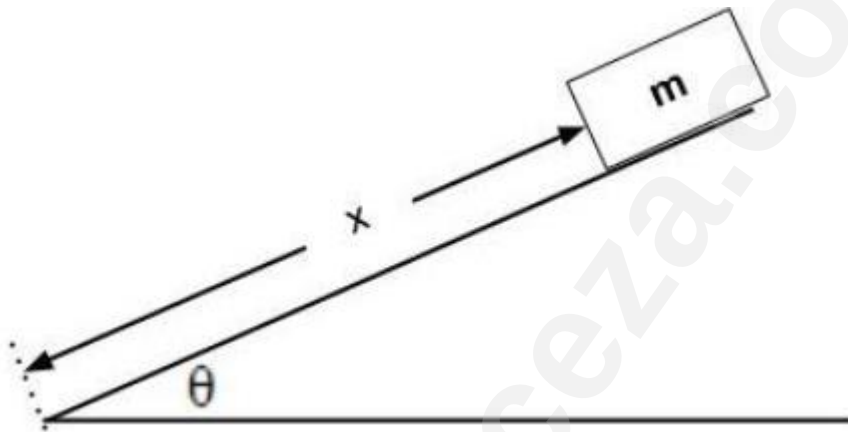
[18]

WORK ENERGY AND POWER

Question 1

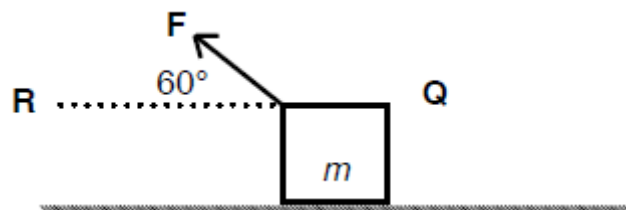
MULTIPLE CHOICE QUESTIONS

1.1 A block, with mass m , is sliding down a rough surface that makes an angle θ with the horizontal, through a distance x as indicated in the sketch below. The net work done on the block will increase if...



- A. a greater frictional force acts on the block
- B. the mass of the block is decreased
- C. the distance x is decreased
- D. the angle θ is increased

1.2 A box, mass m , is at rest on a rough, horizontal surface. A force of constant magnitude F is then applied to the box at an angle of 60° to the horizontal as shown in the sketch.



If the mass has a uniform horizontal acceleration of magnitude a , the frictional force acting on the box is ...



A $F \cos 60^\circ - m a$, in the direction of R.

B $F \cos 60^\circ - m a$, in the direction of Q.

C $F \sin 60^\circ - m a$, in the direction of R.

D $F \sin 60^\circ - m a$, in the direction of Q.

1.3 A constant, resultant force acts on a body which can move freely in a straight line. Which physical quantity will remain constant?

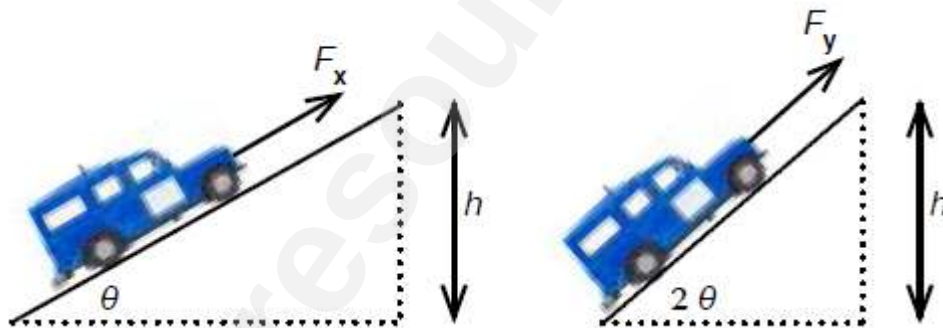
A Acceleration

B Velocity

C Momentum

D Kinetic energy

1.4 Two boys are pulling identical model cars at the same uniform speed up two different inclines, X and Y, of different gradients, but equal height. Friction can be ignored.



The magnitude of the force exerted by each of the boys and the work done can be compared as follows: The magnitude of the force work done is:

A $F_x < F_y$ $W_x > W_y$

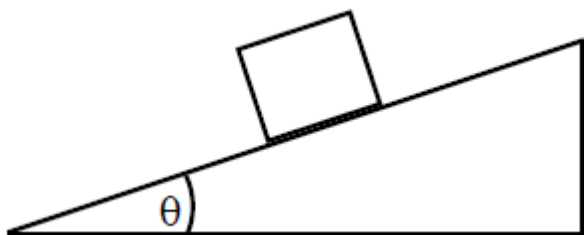
B $F_x > F_y$ $W_x > W_y$

C $F_x < F_y$ $W_x = W_y$

D $F_x > F_y$ $W_x = W_y$

1.5 A body of mass M is at rest on an inclined plane.



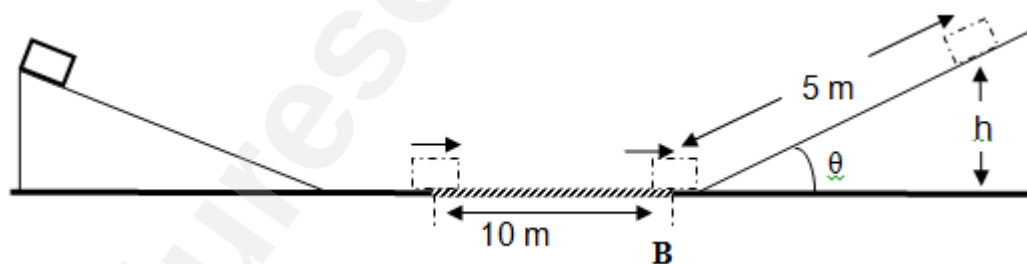


What is the magnitude of the frictional force acting on the body?

- (A) $M g$
- (B) $M g \cos \theta$
- (C) $M g \sin \theta$
- (D) $M g \tan \theta$

Question 2

A 2 kg block initially at 4 m height is released and slides downhill from rest on a frictionless ramp and then moves along a horizontal surface. It then moves on a 10 m length rough horizontal surface with coefficient of friction $\mu=0,2$ until reaches a rough ramp with the same coefficient of friction and slides on it 5 m until it stops.



2.1 State the *law (principle) of conservation of mechanical energy* in words.

2.2 Use the law of conservation of mechanical energy to calculate the speed of the block at the bottom of the ramp.

2.3 State the *work energy theorem* in words.

2.4 Use the WORK ENERGY THEOREM to calculate the speed of the block when passing position B.

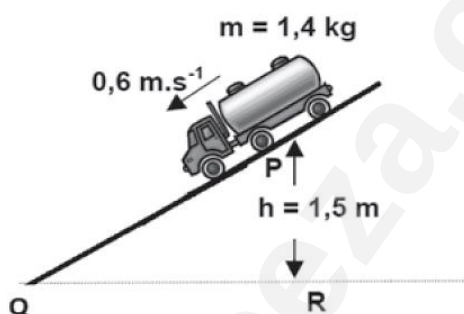


2.5 Use the LAW OF CONSERVATION OF ENERGY to calculate the height reached by the block until it comes to rest.

2.6 Calculate the angle θ .

QUESTION 3

A toy truck, mass $1,4 \text{ kg}$, moving down an inclined track, has a speed of $0,6 \text{ m}\cdot\text{s}^{-1}$ at point P, which is at a height of $1,5 \text{ m}$ above the ground level QR. The curved section of the track, PQ, is $1,8 \text{ m}$ long. When the truck reaches point Q it has a speed of $3 \text{ m}\cdot\text{s}^{-1}$. There is friction between the track and the truck.



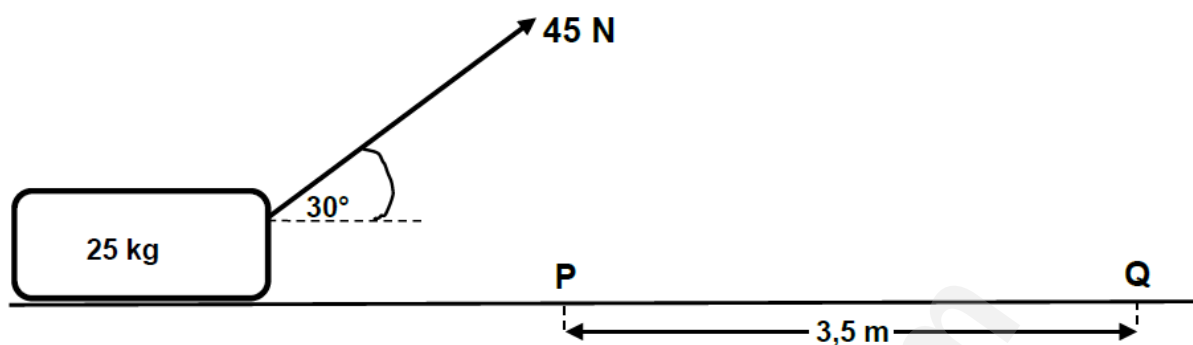
- 3.1 State the principle of conservation of mechanical energy in words. (2)
- 3.2 Is mechanical energy conserved? Explain. (2)
- 3.3 Assume that the average frictional force between the track and the truck is constant along PQ and calculate the average frictional force experienced by the truck as it moves along PQ. (6)

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Question 4

A worker applies a constant force of 45 N on a crate of mass 25 kg , at an angle of 30° with the horizontal. When the crate reaches point P, its velocity is $12 \text{ m}\cdot\text{s}^{-1}$ and $3,5 \text{ m}$ further it reaches point Q at a velocity of $10,8 \text{ m}\cdot\text{s}^{-1}$.





4.1 Draw a labelled free-body diagram to show the horizontal forces acting on the crate during its motion. The length of the vectors should be an indication of their relative magnitudes. (3)

4.2 Write down the NAME of the non-conservative force that opposes the forward motion of the crate. (1)

4.3 State the Work-Energy theorem in words. (2)

4.4 Use ENERGY PRINCIPLES to calculate the magnitude of the non-conservative force mentioned in QUESTION 5.2. (6)

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POWER

Question 5

5.1 An elevator $m = 800 \text{ kg}$ has a maximum load of 600 kg . The elevator goes up 30 m at a constant speed of $4 \text{ m}\cdot\text{s}^{-1}$.

5.1.1 What is the average power output of the elevator motor if the elevator is fully loaded with its maximum weight? (Neglect friction).

5.2 A block of 200 kg is pulled along the floor at a constant speed by an electric motor. The coefficient of friction between the block and the floor is $0,2$.

5.2.1 Calculate the frictional force experienced by the block.

5.2.2 Calculate the power the motor must deliver if the block is to move at a constant speed of $6 \text{ m}\cdot\text{s}^{-1}$.

5.2.3 How much work is done by the motor in 60 s ?

5.2.4 What is the net work done on the block in the 60 s ?

