NOTES

DATE:

SEPTEMBER HOLIDAY REVISION

SEC 3 COMBI SCI (CHEM/PHYS)

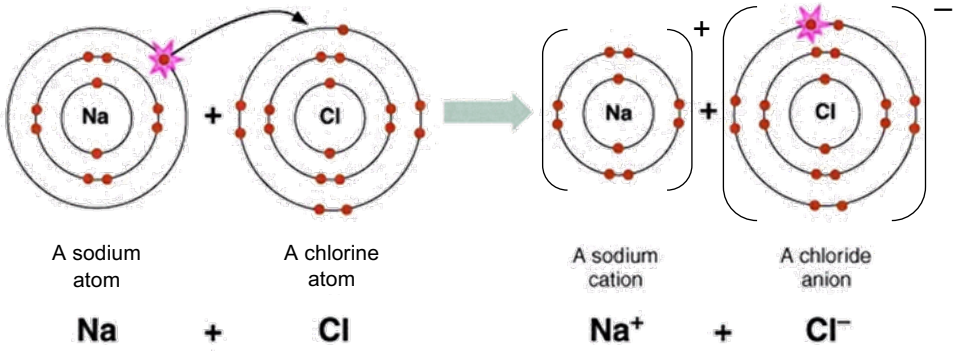
Instructions:
Please complete your Mock Exam Paper under timed conditions and bring it for class.

Chemical Bonding

Atoms **gain or lose electrons** to attain stable electronic configuration (full valence shell).

When atoms lose electrons …	When atoms gain electrons …
number of protons > number of electrons	number of protons < number of electrons
form positive ions (**cations**)	form negative ions (**anions**)

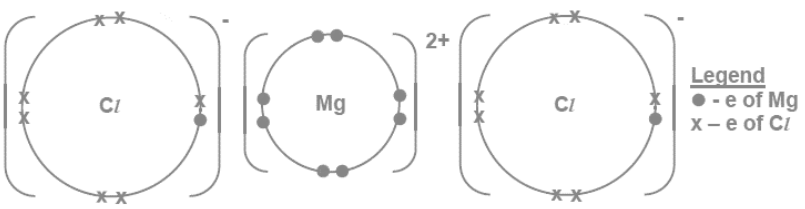
[Ionic Bonding]



Ionic bonding involves the **transfer of electrons**.

- Each sodium atom loses 1 electron to form Na^+ ion.
- Each chlorine atom gains 1 electron to form Cl^- ion.
- Strong electrostatic forces of attraction hold the oppositely charged ions together.

Dot-and-cross diagrams for Ionic compounds



- Ionic charges & brackets
- Full valence shell
- Electrons paired up

[Covalent Bonding]

Apart from gaining or losing electrons, atoms can also **share electrons** to attain stable electronic configuration. This usually occur for non-metal atoms.

Formation of a covalent bond in element (chlorine)

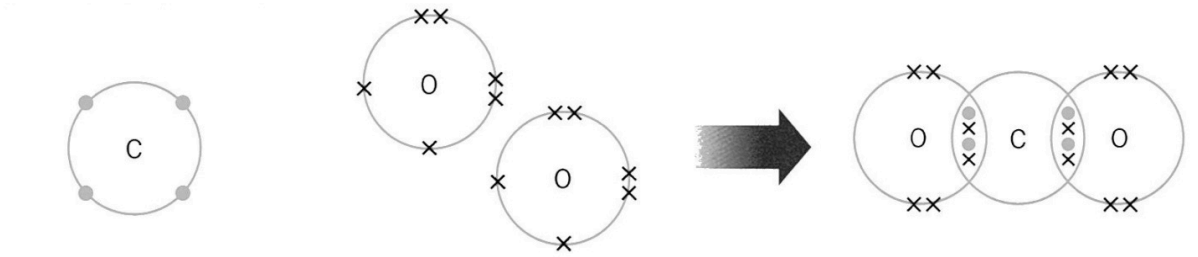
- Each chlorine atom has an electronic configuration of 2.8.7 and require one more electron for stable electronic configuration.
- Each chlorine atom shares one electron from their valence shell.

Two chlorine atoms — One chlorine molecule

- After sharing a pair of electrons, each atom achieved stable electronic configuration!
- This is why chlorine gas exist as a diatomic molecule (group of 2 atoms).

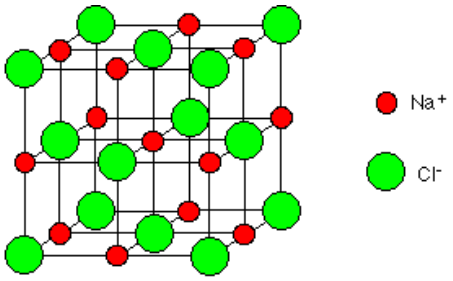
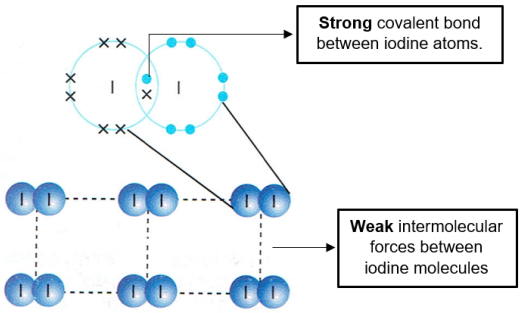
Formation of a covalent bond in compound (carbon dioxide)

- The carbon atom requires four more electrons to obtain stable electronic configuration.
- Each oxygen atom requires two more electrons to obtain stable electronic configuration.
- Carbon shares a total of four electrons while each oxygen atom will share two electrons.



One carbon atom — Two oxygen atoms — One carbon dioxide molecule

[General Properties of substances]

Ionic Compounds	Covalent substances
	
Usually consist of a metal and non-metal	Usually consist of non-metals
<u>High melting point and boiling point</u> • GIANT ionic lattice structure. • LARGE amount of energy is required to overcome the STRONG **electrostatic forces of attraction** between the ions. • Hence, it has a HIGH melting point and boiling point.	**<u>Low melting point and boiling point</u>** • simple molecular structure. • small amount of energy is required to overcome the weak **intermolecular forces of attraction** between the molecules. • Hence, it has a low melting point and boiling point.
Conduct electricity in the molten and aqueous state.	Does not conduct electricity in any state.
Usually soluble in water.	Usually insoluble in water.

Common Mistake

When simple covalent substances are undergoing a state change, heat energy is used to overcome the **WEAK intermolecular forces**. Strong covalent bonds are not broken.

The iodine molecules become further apart. They do not break into iodine atoms after heating.

Chemical Formulae

[Chemical Formulae of Ionic Compounds]

Ionic compounds usually consist of a **positive metal ion (or ammonium)** and a **negative non-metal ion**. The formula of an ionic compound is obtained by **balancing the charges** of the ions.

Ionic compound	Positive ion	Negative ion	Chemical Formula
Sodium chloride	Na^+	Cl^-	$NaCl$
Calcium carbonate	Ca^{2+}	CO_3^{2-}	$CaCO_3$
Potassium sulfate	K^+	SO_4^{2-}	K_2SO_4
Copper(II) hydroxide	Cu^{2+}	OH^-	$Cu(OH)_2$
Aluminium nitrate	Al^{3+}	NO_3^-	$Al(NO_3)_3$

[Chemical Formulae of Covalent substances]

Substances which consist of non-metals only usually have covalent bonds between atoms.

Covalent substance	Chemical Formula	Element or Compound
Hydrogen	H_2	element
Chlorine	Cl_2	element
Iodine	I_2	element
Water	H_2O	compound
Ammonia	NH_3	compound
Carbon **mono**xide	CO	compound
Carbon **di**oxide	SO_2	compound
Sulfur **tri**oxide	SO_3	compound
Carbon **tetra**fluoride	CF_4	compound

Writing Chemical Equations

A balanced chemical equation must contain an **equal number of atoms** of each element on both sides of the equation.

$$CH_4(g) + 2\ O_2(g) \longrightarrow CO_2(g) + 2\ H_2O(l)$$

Reactants **Products**

State symbols

(s): solid (*l*): liquid (g): gas (aq): aqueous, dissolved in water

Guided Examples

hydrogen + oxygen ⟶ water

……

chlorine + potassium iodide ⟶ potassium chloride + iodine

……

sodium + water ⟶ sodium hydroxide + hydrogen

……

Ionic Equations

should:

- balance charges on both sides of the equations
- include any solids, liquids and gases
- write state symbols

should not:

- include spectator ions

Acids and Bases

Acids	Alkalis
Produce hydrogen (H^+ ions) when dissolved in water	Produce hydroxide (OH^- ions) when dissolved in water
Turns damp **blue** litmus paper **red**	Turns damp **red** litmus paper **blue**
pH < 7	pH > 7
Hydrochloric acid (HCl) Sulfuric acid (H_2SO_4) Nitric acid (HNO_3)	Sodium hydroxide (NaOH) Potassium hydroxide (KOH) Aqueous ammonia (NH_4OH)
Ionic Equation for Neutralisation: $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$	

- Bases include **metal oxides** and **metal hydroxides**.
  - A base that is **soluble in water** is called an **alkali**.
- **Calcium hydroxide** can be used to **neutralise excess acidity in the soil**.

General equations

1. acid + metal ⟶ salt + hydrogen gas
2. acid + base ⟶ salt + water
3. acid + **carbonate** ⟶ salt + water + **carbon dioxide**
4. **ammonium** salt + alkali ⟶ salt + water + **ammonia** gas (NH_3)

Metal oxides		Non-metal oxides	
Amphoteric	**Basic**	**Neutral**	**Acidic**
React with acids and alkalis	React with acids only	Do not react with acids or alkalis	React with alkalis only
ZnO, Al_2O_3, PbO **[ZAP]**	Other metal oxides that are not [ZAP]	CO, NO, H_2O	Other non-metal oxides that are not CO, NO or H_2O

Kinematics

Speed : change in distance per unit time	$s = \frac{d}{t}$
	$\text{Average Speed} = \frac{\text{Total Distance}}{\text{Total Time}}$
Velocity : rate of change of displacement	$v = \frac{d}{t}$
Acceleration : rate of change of velocity	$a = \frac{v_f - v_i}{t}$

[Uniform Acceleration]

Time (s)	1	2	3	4
Velocity (m/s)	5	10	15	20

Velocity of object **increases by 5 m/s** every second. **Acceleration = 5 m/s^2**.

Time (s)	1	2	3	4
Velocity (m/s)	50	40	30	20

Velocity of object **decreases by 10 m/s** every second. **Acceleration = –10 m/s^2**

The object is slowing down/decelerating. **Deceleration = 10 m/s^2** (no negative)

[Non-Uniform Acceleration]

Time (s)	1	2	3	4
Velocity (m/s)	5	10	20	40

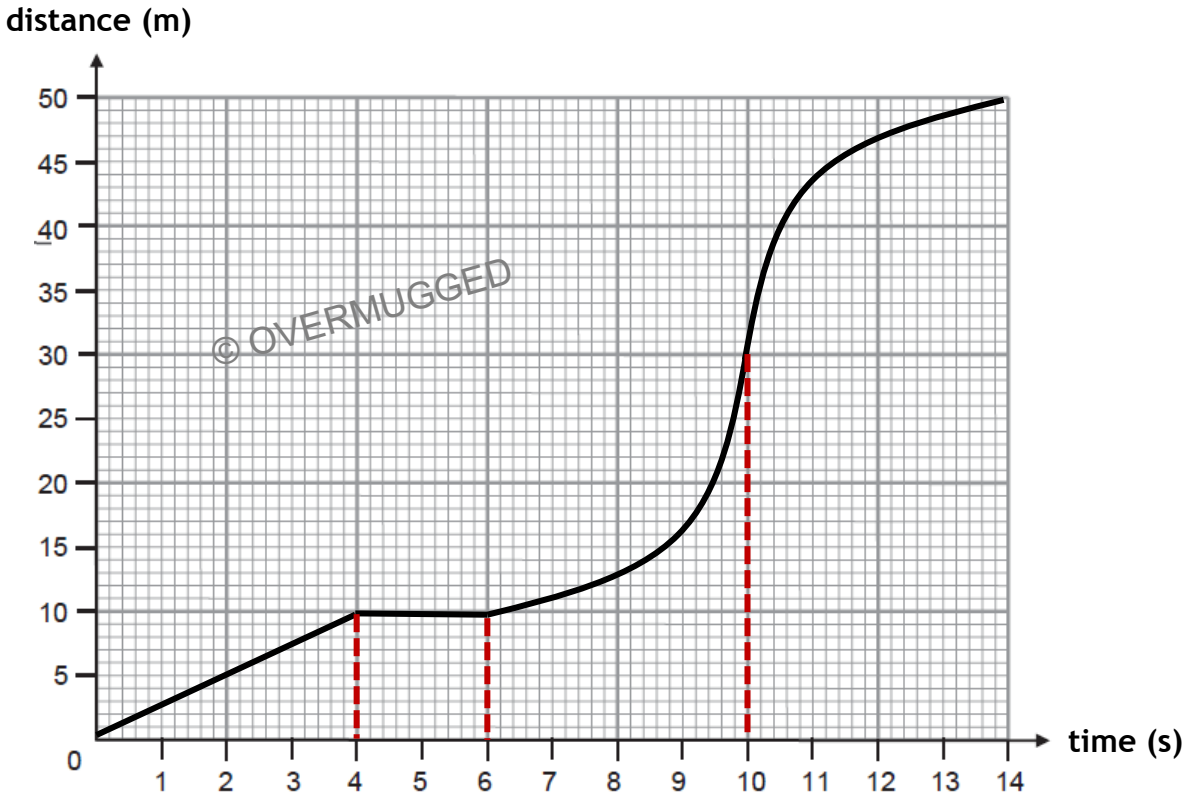
Change in velocity is not the same every second.

[Free-fall]

If **air resistance is ignored**, all objects will **accelerate uniformly at 10 m/s^2** to the centre of the earth (speed increase by 10 m/s every second).

When a bowling ball and feather is released from the same height, they will **hit the ground at the same time if there is no air resistance / in space or vacuum.**

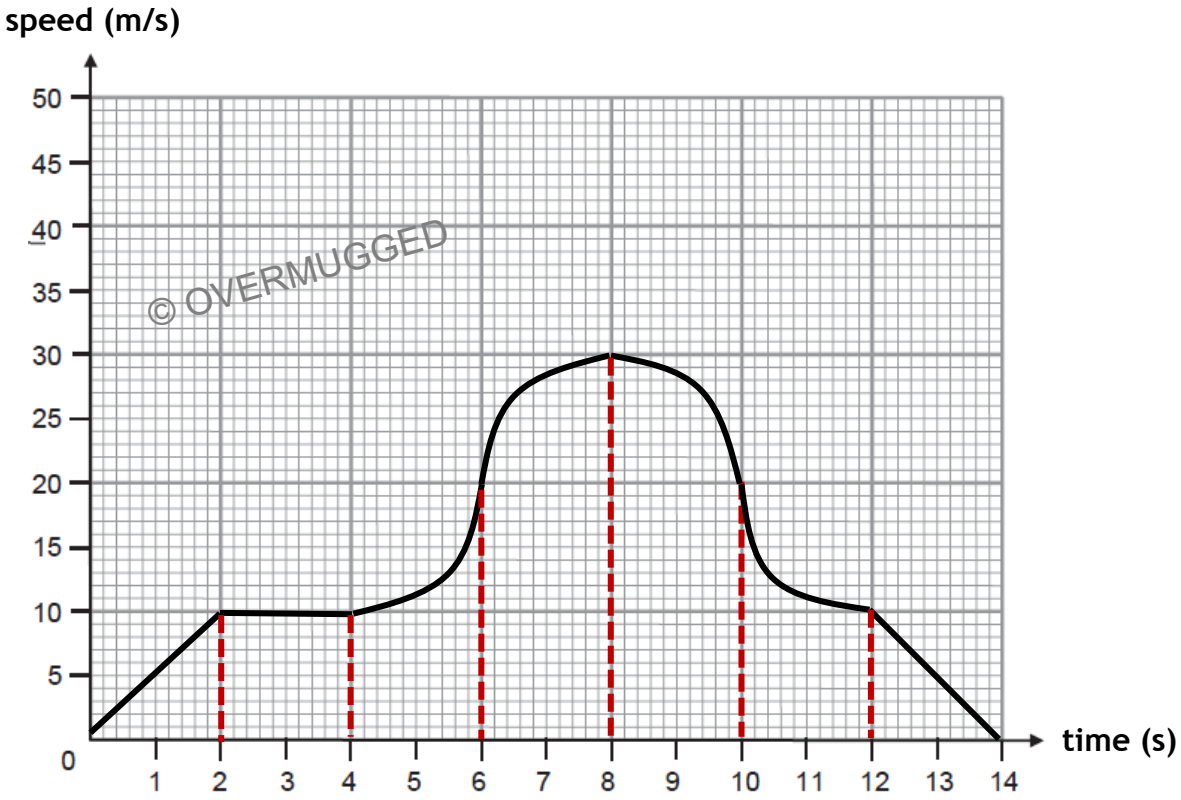
[Distance – Time Graph]



Gradient of a distance – time graph represents **speed**.

Time Period	Gradient	Motion
t = 0 to t = 4	**Constant**	Object moving at **constant** speed.
t = 4 to t = 6	Zero	Object is at rest/stationary.
t = 6 to t = 10	**Increasing** (Steeper)	Object is moving at **increasing** speed.
t = 10 to t = 14	**Decreasing** (Less steep)	Object is moving at **decreasing** speed.

Speed – Time Graph



Gradient of a speed – time graph represents **acceleration**.

Area under the graph represents **distance**.

Area of trapezium = $\frac{1}{2}(a + b)\,h$

Time Period	Gradient	Motion
t = 0 to t = 2	**Constant**	**Constant** acceleration
t = 2 to t = 4	Zero	Constant speed
t = 4 to t = 6	**Increasing**	**Increasing** acceleration
t = 6 to t = 8	**Decreasing**	**Decreasing** acceleration
t = 8 to t = 10	**Increasing**	**Increasing** deceleration
t = 10 to t = 12	**Decreasing**	**Decreasing** deceleration
t = 12 to t = 14	**Constant**	**Constant** deceleration

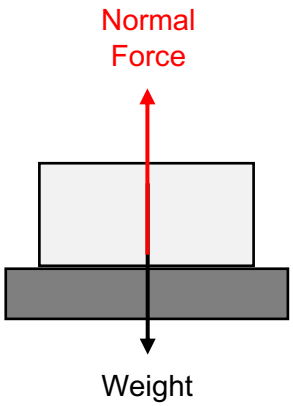
Positive gradient ⟶ object is **accelerating**

Negative gradient ⟶ object is **decelerating**

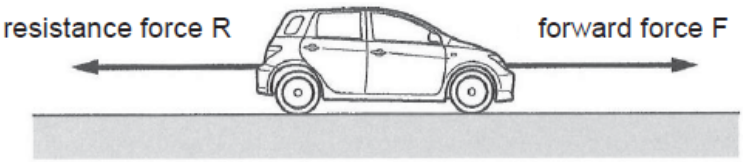
Dynamics

[Newton's first law – Balanced forces]

An object remains at rest or continue moving at constant speed unless a resultant force acts on it.



An object placed on the table **remains at rest**.

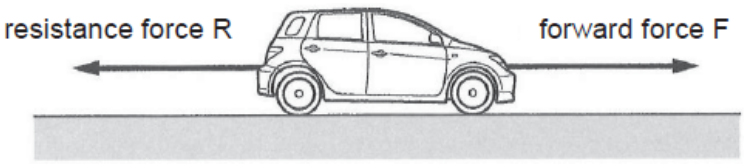


A moving car continues to **move at constant speed** if forward force equals to resistive force.

[Newton's second law – Unbalanced forces]

When a resultant force acts on an object of constant mass, the object will accelerate in the direction of the resultant force. The product of the mass and acceleration of the object gives the resultant force.

$$F_R = ma$$



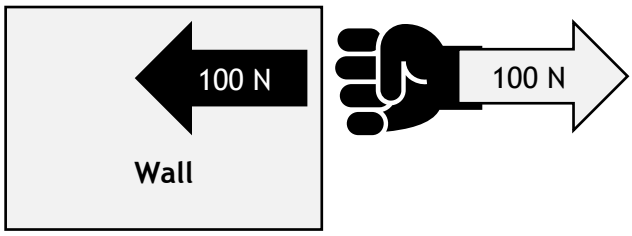
F > R	F < R
Car will accelerate in the forward direction.	Car will decelerate and slow down.

[Newton's third law – Action Reaction Pair]

If **body A** exerts a force (F_{AB}) on **body B**, then **body B** will exert an equal and opposite force (F_{BA}) on **body A**.

In other words, for every action, there is an equal and opposite reaction.

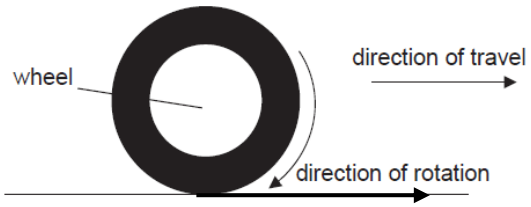
Example of Newton's 3rd Law



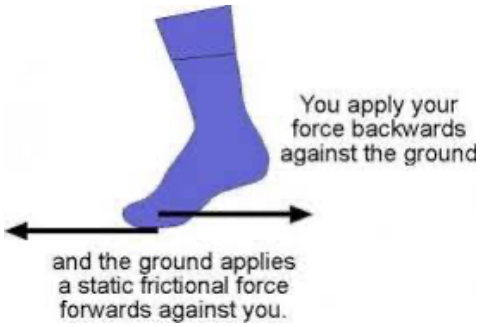
If you punch the wall with 100 N, the wall will exert 100 N force on your hand.

[Friction]

Friction is a contact force which opposes motion between surfaces that are in contact with each other.



Friction



Positive effects of friction	Negative effects of friction
Walking without slipping	Wear and tear
Allow vehicles to slow down	Reduced efficiency

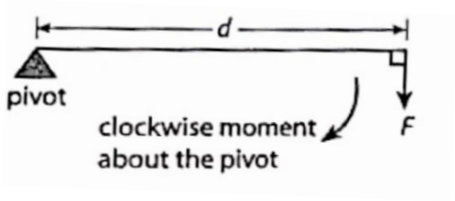
Moments

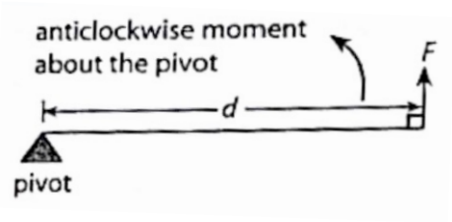
[Moments]

A force may cause an object to turn. This turning effect of a force is known as **moment**.

definition	Product of the force and the **perpendicular distance** from the pivot to the line of action of the force.
S.I unit	newton metre (Nm)
formula	**Moment = F × d**

Note: Moment is a vector and can be described as **clockwise** or **anticlockwise**.





[Principle of Moments]

When a body to be in equilibrium/balanced, the sum of the clockwise moments about a pivot is equal to the sum of anticlockwise moments about the same pivot.

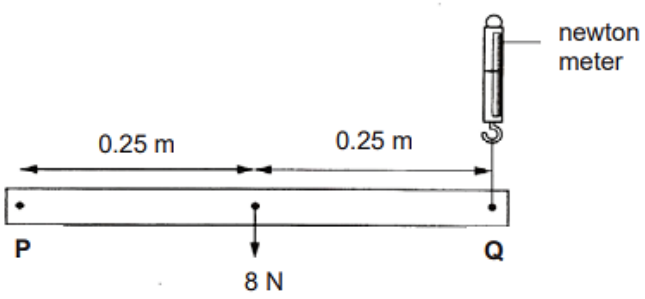
total clockwise moments = total anticlockwise moments

Hence, objects remain stationary and do not rotate.

Worked Example

A metal bar, **PQ**, has a weight of 8 N and is pivoted at **P**.

It is prevented from turning by a newton meter acting at **Q**.



Calculate the reading on the newton meter.

Thought process:

- The weight of the metal bar (8N) will cause the bar to turn clockwise about pivot P.
- To prevent the bar from turning clockwise, there must be something causing it to turn anticlockwise by the same amount (newton meter providing upward force).
- According to principle of moments, clockwise moment = anti-clockwise moment

$$0.25 \times 8 = F \times (0.25 + 0.25)$$

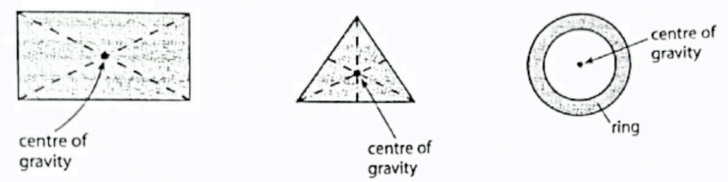
$$2 = 0.5\ F$$

$$\mathbf{F = 4\ N}$$

[Centre of Gravity]

A point where the whole weight of the object appears to act.

- for an object of regular shape and uniform density, the centre of gravity is at its geometrical centre.
- the centre of gravity of an object may lie outside the object.



END OF YEAR MOCK EXAMINATION
SECONDARY THREE
BASED ON 2024 SEAB SYLLABUS

COMBINED CHEMISTRY 5086

September 2024
30 minutes

READ THESE INSTRUCTIONS FIRST

Write your answer in dark blue or black pen.
Do not use staples, paper clips, glue or correction fluid.

There are **ten** MCQ questions and **three** open-ended questions. Answer **all** questions.
For each question, there are four possible answers A, B, C and D.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this question paper.

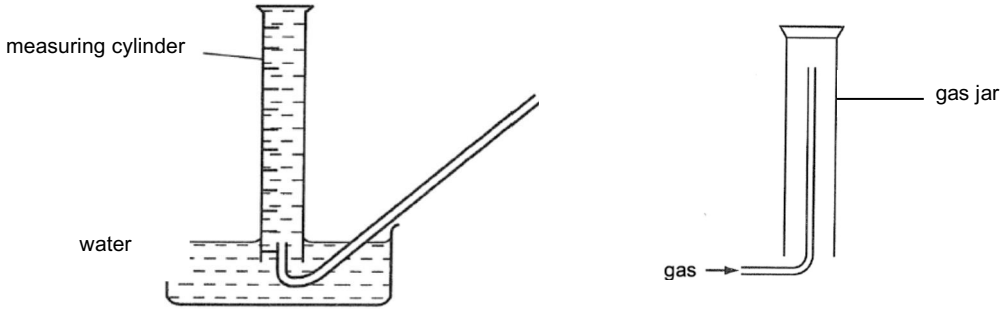
The use of an approved scientific calculator is expected, where appropriate.

SCORE

MCQ		10
Open-ended		15
TOTAL		25

Question 1

The diagrams show two methods of collecting gases.



Which row gives the properties of a gas which can be collected by both methods?

	solubility in water	**density**
(A)	soluble in water	denser than air
(B)	soluble in water	less dense than air
(C)	insoluble in water	denser than air
(D)	insoluble in water	less dense than air

Question 2

Sodium chloride crystals can be separated from sand using the four steps shown below.

Which of the following shows the steps in the correct order?

(A) dissolve → evaporate → filter → crystallise

(B) dissolve → filter → evaporate → crystallise

(C) filter → crystallise → evaporate → dissolve

(D) filter → evaporate → crystallise → dissolve

Question 3

The table shows the melting and boiling points of four substances.

In which substance are the particles vibrating about their fixed position at 22 °C?

	melting point / °C	**boiling point / °C**
(A)	−110	−50
(B)	−4	25
(C)	0	100
(D)	58	203

Question 4

An aluminium ion is represented by the symbol, Al^{3+}.

Which row correctly states the number of neutrons, protons and electrons the ion has?

	neutrons	**protons**	**electrons**
(A)	14	13	10
(B)	14	13	13
(C)	27	14	13
(D)	40	13	10

Question 5

Atom **M** has an electronic configuration 2, 5.

Atom **N** has an electronic configuration 2, 8, 5.

Which statement about element **N** is correct?

(A) **N** has more electron shells than **M**.

(B) **N** has more electrons in its outer shell than **M**.

(C) **N** is in the same period of the Periodic Table as **M**.

(D) **N** is in a different group of the Periodic Table from **M**.

Question 6

The table below gives information about the electrical conductivity of four substances.

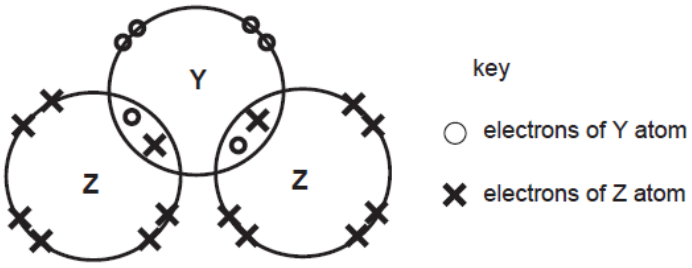
substance	electrical conductivity
M	not able to conduct
N	not able to conduct
p	good conductor when molten or dissolved in water
Q	good conductor when solid or molten

Which of the following are possible identities for the four substances?

	M	N	P	Q
(A)	chlorine	sodium	carbon dioxide	sodium chloride
(B)	chlorine	carbon dioxide	sodium chloride	sodium
(C)	carbon dioxide	chlorine	sodium	sodium chloride
(D)	carbon dioxide	sodium chloride	sodium	chlorine

Question 7

The diagram shows the arrangement of electrons in the outer shells of the atoms in the compound YZ_2.

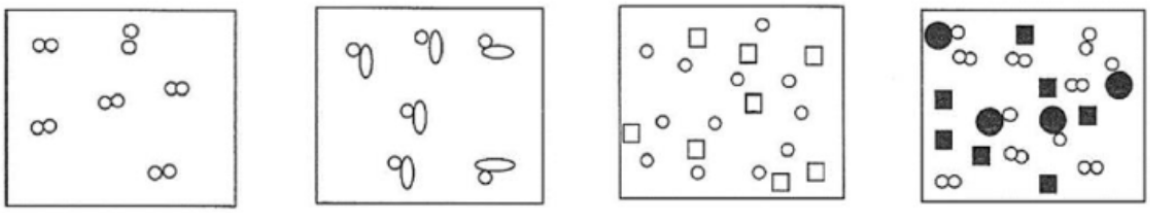


Which pair of elements could be **Y** and **Z**?

	Y	Z
(A)	calcium	fluorine
(B)	carbon	sulfur
(C)	oxygen	hydrogen
(D)	sulfur	chlorine

Question 8

The diagram represents four different substances.



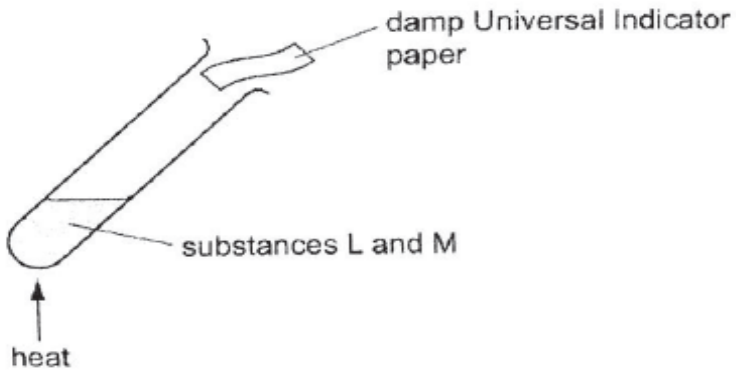
I II III IV

Which row is correct?

	pure element	mixture of elements	pure compound	mixture of elements and compound
(A)	I	III	II	IV
(B)	IV	I	II	III
(C)	I	II	III	IV
(D)	II	IV	I	III

Question 9

The diagram shows two substances, **L** and **M**, being heated together.



The damp universal indicator turns blue during experiment. What are **L** and **M**?

(A) hydrochloric acid and ammonium nitrate

(B) hydrochloric acid and sodium carbonate

(C) sodium hydroxide and ammonium nitrate

(D) sodium hydroxide and sodium carbonate

Question 10

Which row correctly describe the following oxides?

	sodium oxide, Na_2O	**carbon dioxide, CO_2**	**aluminium oxide, Al_2O_3**
(A)	basic	neutral	basic
(B)	basic	acidic	amphoteric
(C)	acidic	basic	basic
(D)	acidic	neutral	amphoteric

Write your answers in the spaces below.

Question 11

The table shows the atomic structure of particles, **A** to **E**.

The letters of these particles are **not** the symbol of the elements.

particle	no. of protons	no. of electrons	nucleon number
A	7	10	14
B	8	8	16
C	8	8	18
D	10	10	20
E	11	10	23

Table 11.1

(a) (i) Using the information provided in Table 11.1, explain why particle **B** and **C** are isotopes of the same element. [1]

(ii) Explain why particle **B** and particle **C** have the same chemical properties. [1]

(b) State the electronic configuration of particle D. Explain why it is unreactive. [2]

(c) Which of these particles is negatively charged? Explain your answer. [2]

Question 12

Sodium can react with sulfur to form sodium sulfide.

(a) Draw a 'dot-and-cross' diagram to show the arrangement of the valence shell electron for sodium sulfide. [2]

[Proton number: Na-11, S-16]

(b) Sulfur can also react with carbon to form carbon disulfide, CS_2.

(i) Predict whether carbon disulfide is a good conductor of electricity. Explain your answer. [1]

(ii) Explain, using ideas about structure and bonding, why carbon disulfide exists as a gas at room temperature. [2]

Question 13

A chemical reaction can occur when magnesium is added into hydrochloric acid.

(a) (i) Name the type of reaction that occurred. [1]

(ii) Write a balanced chemical equation for the reaction between magnesium and hydrochloric acid. [1]

(b) Acid rain can cause the soil to become too acidic and unsuitable for plant growth.

Name the substance that farmers can add to the soil and describe how it affects the pH of the soil. [2]

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SECONDARY THREE
BASED ON 2024 SEAB SYLLABUS

COMBINED PHYSICS 5087

September 2024
30 minutes

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Open-ended		15
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Question 1

Which change will increase the period of a pendulum?

(A) Using a longer pendulum

(B) Using a shorter pendulum

(C) Using a pendulum bob of greater mass

(D) Releasing the pendulum bob at a greater angle

Question 2

Which of the following rows is correct?

	scalar	**vector**
(A)	acceleration	speed
(B)	acceleration	force
(C)	distance	displacement
(D)	time	mass

Question 3

If an object was brought from Earth to the Moon, how will its mass, weight and density of the object change?

	Mass	**Weight**	**Density**
(A)	Decreases	Remains the same	Increases
(B)	Decreases	Decreases	Remain the same
(C)	Remains the same	Decreases	Remains the same
(D)	Remains the same	Remains the same	Increases

Question 4

The diagram below shows an iron bar with a density of 8.0 g/cm^3.

The iron bar is melted and made into 4 equal cubes. What is the density of each iron cube?

(A) 2.0 g/cm^3

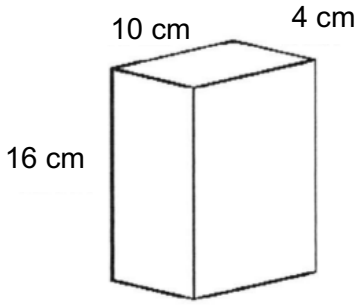
(B) 4.0 g/cm^3

(C) 8.0 g/cm^3

(D) 32 g/cm^3

Question 5

A brick of mass 5 kg stands upright on the ground as shown.
The gravitational field strength, g, is 10 N/kg.



What is the smallest possible pressure it can exert on the ground?

(A) $\frac{5}{4 \times 10}$ N/cm^2

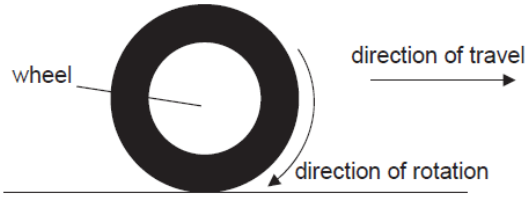
(B) $\frac{5 \times 10}{4 \times 10}$ N/cm^2

(C) $\frac{5}{10 \times 16}$ N/cm^2

(D) $\frac{5 \times 10}{10 \times 16}$ N/cm^2

Question 6

A car is accelerating along a road in the direction shown. The wheel shown is connected to the engine.

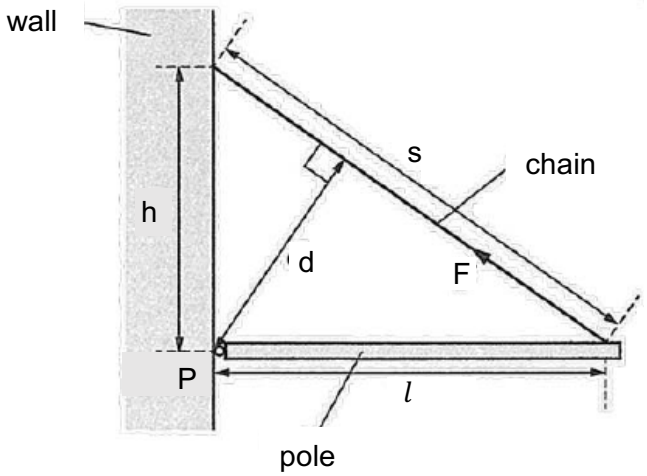


Which row shows the correct direction of air resistance on the car and friction acting on the wheel?

	air resistance	friction
(A)	←	←
(B)	←	→
(C)	→	←
(D)	→	→

Question 7

A horizontal pole is attached to the wall of a building. A chain is connected from the end of the pole to a point higher up the wall and *F* is the tension force.



What is the moment produced by force *F* about the pivot P?

(A) F x d

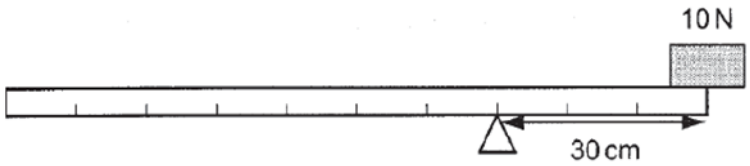
(B) F x h

(C) F x *l*

(D) F x s

Question 8

A uniform bar of length 1.0m is supported 30 cm from one end. In order to balance the bar, a weight of 10 N is glued on its end as shown.



What is the weight of the bar?

(A) 4.3 N

(B) 6 N

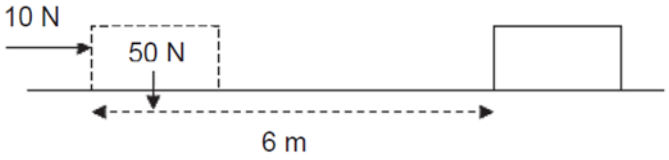
(C) 15 N

(D) 20 N

Question 9

A box weighing 50 N is being pushed horizontally on a smooth surface by a 10 N force for 6 m in 10 s.

What is the average power used to push the box?



(A) 6 W

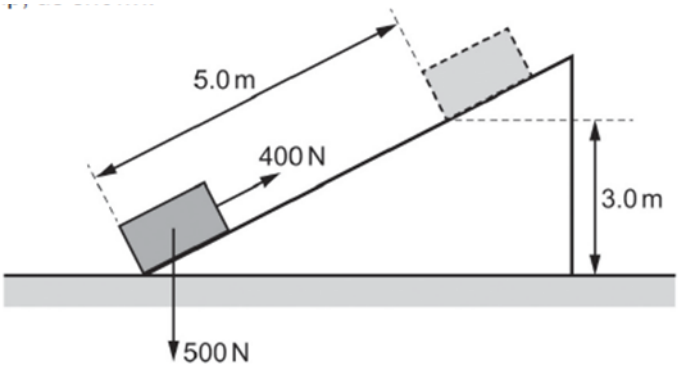
(B) 30 W

(C) 60 W

(D) 300 W

Question 10

Work is done when a force of 400 N pulls a crate of weight 500 N at a constant speed along a ramp as shown.



Part of the work done increases the energy in the gravitational potential store of the crate, ***E***, and the rest is work done, ***W,*** against friction.

What are the values of ***E*** and ***W***?

	E/J	**W/J**
(A)	1500	500
(B)	1500	2000
(C)	2000	2500
(D)	3500	500

Write your answers in the spaces provided.

Question 11

Figure 11.1 shows how the speed of a car changed with time on a straight road.

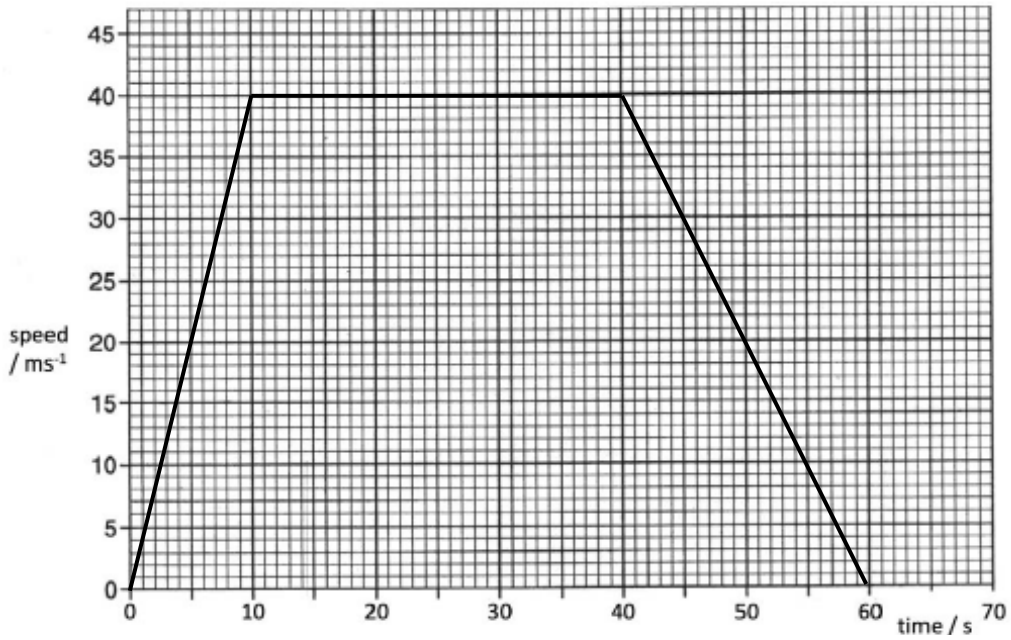


Figure 11.1

(a) Calculate the deceleration of the car. [2]

deceleration = ...

(b) Calculate the total distance travelled by the car. [2]

total distance = ...

(c) Hence, calculate the average speed of the car for the whole journey. [1]

average speed = ...

Question 12

Figure 12.1 shows two horizontal forces acting on a car. The car has a mass of 1300 kg.

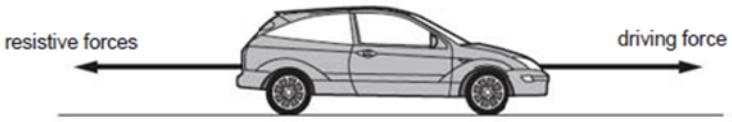


Figure 12.1

(a) Explain, in terms of forces acting on the car, why the car moves at constant speed even though there is a constant driving force. [2]

(b) At one point of the journey, the car has a uniform acceleration of 2.5 m/s^2.

(i) Calculate the resultant force acting on the car when it is accelerating. [2]

resultant force = ...

(ii) If the car experiences a resistive force of 1250 N, calculate the driving force of the car. [1]

driving force = ...

Question 13

Figure 13.1 below shows a 500 kg cart on a roller coaster.

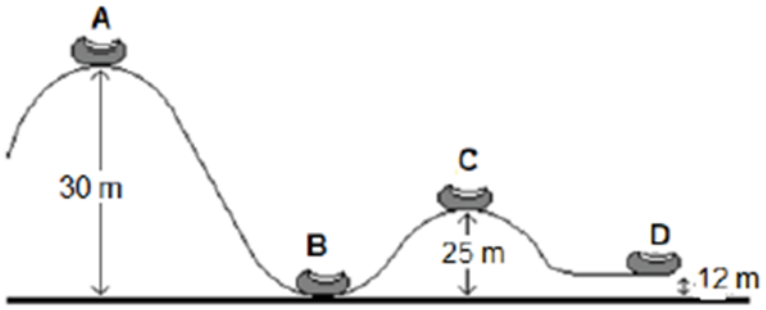


Figure 13.1

(a) The cart is initially at rest at point A. Calculate the

(i) amount of energy in the gravitational potential store of the cart at A. [1]

gravitational potential energy = …….…….……

(ii) maximum speed that the cart can reach when it reaches point B. [3]

speed = …….…….……

(b) Explain why it is not possible for the cart to reach this speed in reality. [1]

_____

_____

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Bukit Timah	Wednesday	7.30PM-9.30PM
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