PHYSICAL SCIENCES

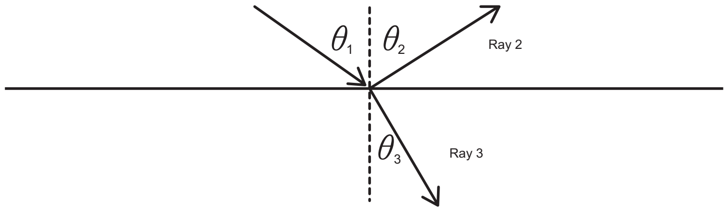
Worksheet Booklet

GRADE 11 TERM 2

TOPIC 5: Geometrical Optics:

GRADE 11: WORKSHEET

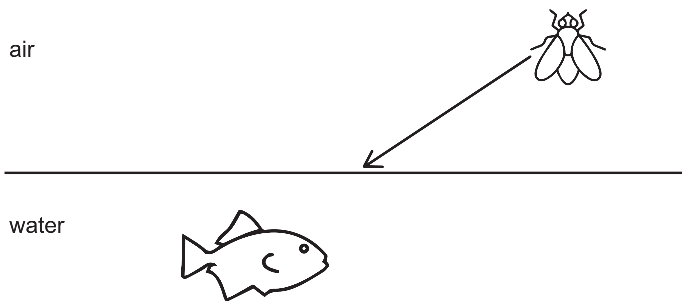
1. Consider light traveling in air towards an air/water boundary, as pictured below. Which of the following best describes the reflected ray 2?



A No light will be reflected, so ray 2 does not exist.
B Some light will be reflected and $\theta_1 = \theta_2$.
C All light will be reflected and $\theta_1 > \theta_2$.
D Some light will be reflected and $\theta_1 < \theta_2$. (2)

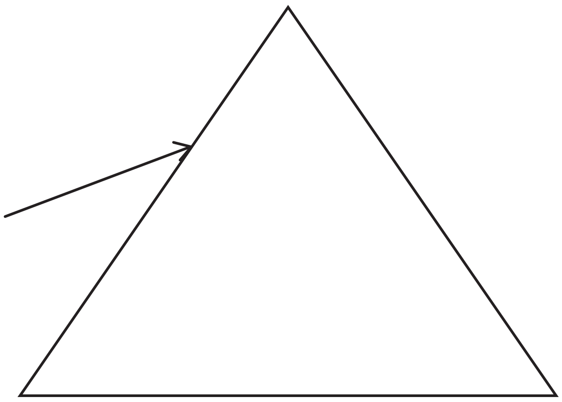
2. Consider the situation pictured in Q1, above. Which of the following would best describe the situation with the refracted ray and the angle of refraction, θ_3?
A $\theta_1 = \theta_3$.
B $\theta_1 > \theta_3$.
C $\theta_1 < \theta_3$.
D no light will be refracted as it is all reflected. (2)

3. Light is going from an insect into water, as pictured below.



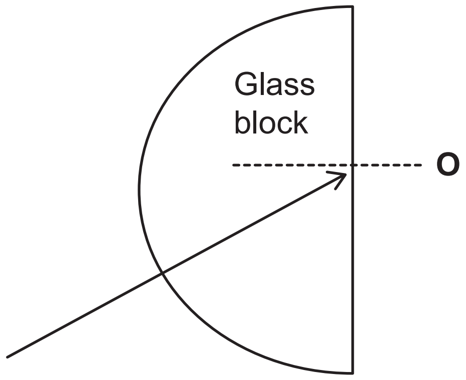
3.1 Define the term 'refraction' (2)
3.2 Why does the light ray change direction? (1)
3.3 In which direction does the light ray bend? (1)
3.4 Complete the ray diagram to show how the ray of light reaches the fish's eye. (3)
3.5 Where would the insect appear to be to the fish? Show this on your diagram. (2)
3.6 A friend of yours says that light always travels in straight lines. How would you respond to them? (2)

4. Complete the following ray diagram to illustrate the path of the light.
Include the following labels in your sketch:
incident ray, emergent ray, refracted ray, normal lines, angles of incidence and refraction and angle of deviation. (9)



5. Consider a ray of light entering a semi-circular glass block, as shown below

5.1 Complete the following ray diagram: (2)



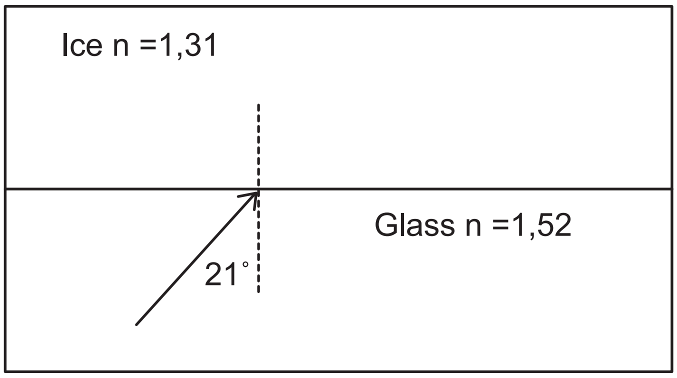
5.2 Which medium has a higher optical density, the glass or the air? (1)

5.3 The ray does not bend when it enters the semi-circular block.

5.3.1 What does this tell you about the angle of incidence? Explain your answer. (3)

5.3.2 What does this tell you about point **O**? (1)

6. In the diagram below (not to scale), a ray of light, is travelling from glass towards the boundary with ice.



6.1 The angle on incidence is 21°. Copy and complete the ray diagram for the ray at the boundary of the glass and ice. (3)

6.2 Write down the equation for Snell's Law (1)

6.3 Calculate the critical angle for light going from glass into ice. (3)

6.4 How does the speed of light in the glass compare to speed of light in ice? (2)

7. In an experiment, light goes from air to diamond. The angle of incidence is 21° and the angle of refraction is 60°.

   7.1 State Snell's law. (2)

   7.2 The refractive index for air is 1,00. Calculate the refractive index for this diamond. (4)

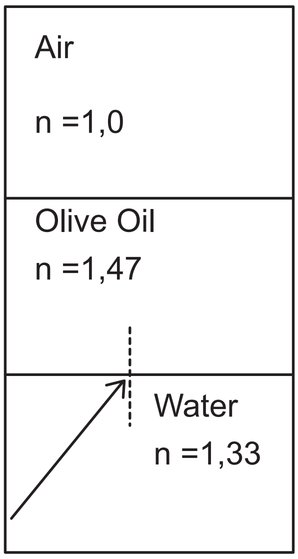
   7.3 Calculate the speed of light in diamond. (3)

8. What 2 criteria are needed for total internal reflection to occur? (2)

   8.1 Explain how an optical fibre uses total internal reflection. (2)

   8.2 Give two practical uses for optical fibres? (2)

9. Consider a ray of light traveling through water into olive oil and then into air, as pictured below.



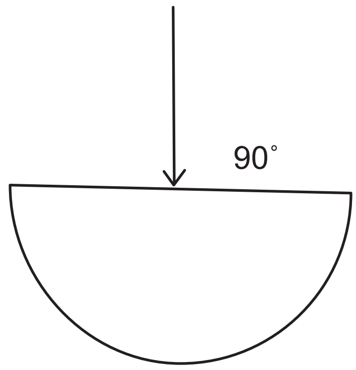
   9.1 Redraw and complete the path of the ray through the 3 mediums. (4)

   9.2 Explain why the ray changed direction as it goes from the water into the olive oil. (2)

TOPIC 5: Geometrical Optics:

GRADE 11: CONSOLIDATION QUESTIONS TOTAL: 54 MARKS

1. Light goes from air into a glass circular prism as shown below, at 90° to the surface of the prism. Which of the flowing best describes and explains the path of the ray inside the prism?

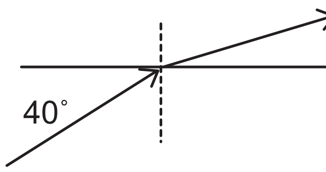


	Path of the ray	Explanation
A	Light bends towards the normal	The glass is optically more dense than the air.
B	Light bends away from the normal	The glass is optically more dense than the air.
C	Light does not bend	The ray is travelling along the normal.
D	Light does not bend	The air and the glass have the same optical density.

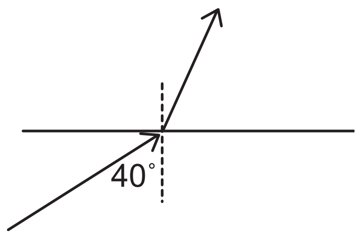
(2)

2. A light ray travels from medium P to medium Q. Medium Q has a lower refractive index than medium P. The critical angle for this situation is 42°. Which one of the following sketches represents the correct path of the ray?

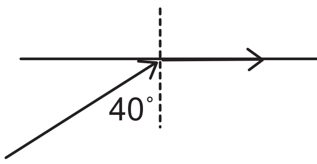
A



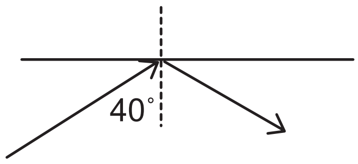
B



C

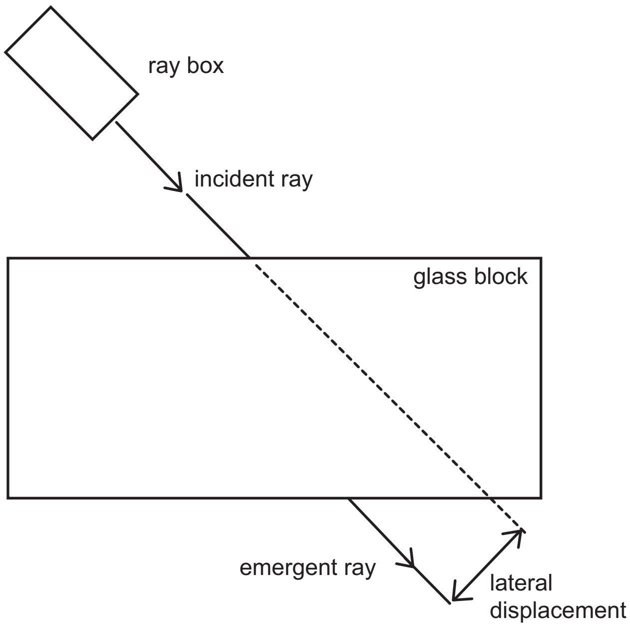


D



(2)

3. The diagram below shows a ray box and a rectangular glass block placed on a sheet of paper.



The ray is laterally displaced when it leaves the block as shown below.

a. Explain why the ray is laterally displaced. (1)

b. Explain why the emergent ray is parallel to the incident ray. (2)

c. Complete the diagram (3)

d. If the block is placed in a medium of liquid carbon disulphide, which has a higher optical density than the block, redraw the diagram with the incident and refracted rays. (3)

4. During an investigation into Snell's law, a ray of light was passed from one medium into another. The angle of incidence was measured, as was the angle of refraction. The refractive index for each material was found, and all the results are recorded in the table below.

Material 1	**Material 2**	n_1	n_2	$\frac{n_1}{n_2}$	θ_1	$\sin\theta_1$	θ_2	$\sin\theta_2$	$\frac{\sin\theta_2}{\sin\theta_1}$
water	air	1,33	1,0		25		34,2		
75% sugar solution	water	1,47	1,33		25		27,8		
diamond	water	2,42	1,33		25		50,3		
75% sugar solution	diamond	1,47	2,42		25		14,9		

a. Calculate the ratio $\frac{n_1}{n_2}$ for each of the four experiments. (4)

b. Is there a relationship between $\frac{n_1}{n_2}$ and θ_2? State this relationship. (2)

c. Draw the graph of $\frac{n_1}{n_2}$ and θ_2, with $\frac{n_1}{n_2}$ on the x axis. (4)

d. Complete the table by calculating $\sin\theta_1$, $\sin\theta_2$ and $\frac{\sin\theta_2}{\sin\theta_1}$. (8)

e. Draw the graph of $\frac{n_1}{n_2}$ and $\frac{\sin\theta_2}{\sin\theta_1}$ with $\frac{n_1}{n_2}$ on the x axis. (4)

f. State the relationship between $\frac{n_1}{n_2}$ and $\frac{\sin\theta_2}{\sin\theta_1}$. (2)

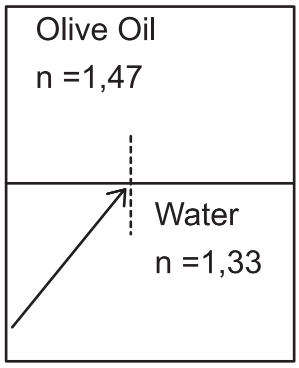
g. Compare this relationship to Snell's law. (2)

5. The diagram below shows an optical fibre used for data transmission.

a. The speed of light in a vacuum is $3,0 \times 10^8 m.s^{-1}$. Calculate the speed of light in the fibre of refractive index 1,52. (3)

b. Calculate the minimum time taken for a pulse of light to travel along a straight optical fibre of length 3000 m and refractive index 1,52. (3)

6. Consider a ray of light traveling through water into olive oil and then into air, as pictured below.



6.1 Calculate the speed of light through olive oil (3)

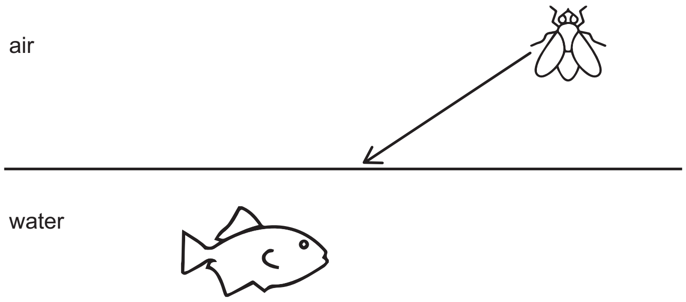
6.2 The angle of incidence in the water is 37°. Calculate the angle of refraction. (4)

6.3 What does the refractive index of the oil tell us about the optical density of the oil compared to the water? (2)

TOPIC 5: Geometrical Optics:

GRADE 11: CONSOLIDATION WORKSHEET MEMORANDUM

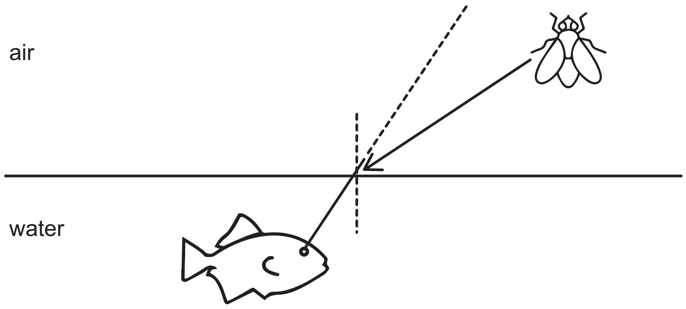
1. B✓✓ Some light will be reflected and it will obey the law of reflection (2)
2. C✓✓ The refracted ray will bend towards the normal (2)
3. Light is going from an insect into water, as pictured below.



3.1 The change of direction of a light ray ✓ because its speed changes ✓when it passes from one medium into another. (2)

3.2 Because it's speed changes. ✓ (1)

3.3 Towards the normal. ✓ (1)

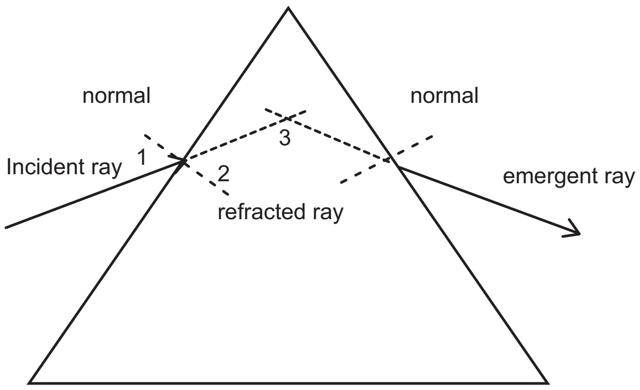


3.4 ✓ for ray bending
✓ for bending towards normal
✓ for normal. (3)

3.5 See above; refracted ray appears to be straight ✓; similar length of incident and apparent rays ✓. (2)

3.6 Light does not always travel ✓ in straight lines, it can be refracted or reflected ✓. (2)

4. (9)

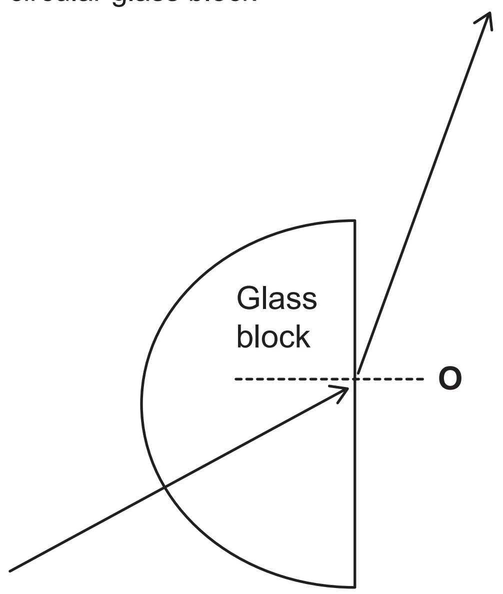


1 – angle of incidence ✓; 2- angle of refraction ✓; 3 – angle of deviation ✓

✓ for refacted ray on diagram; ✓ for emergent ray on diagram

5. Semi-circular glass block

5.1 (2)



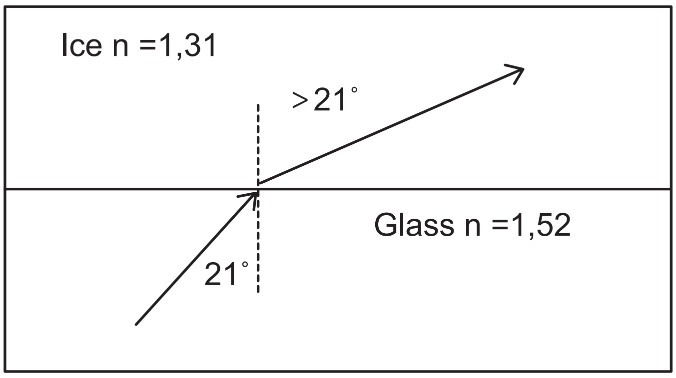
Ray must bend away from the normal ✓✓

5.2 The glass ✓ (1)

5.3 5.3.1 angle of incidence = 0 ✓ (along normal) Because otherwise it would bend towards the normal. ✓ (3)

5.3.2 **O** is the centre of the diameter. ✓ (1)

6.



6.1 ✓ for refracted ray; ✓ ray bends away from normal; ✓ for indication of angle of refraction. (3)

6.2 $n_1 \sin\theta_1 = n_2 \sin\theta_2$ ✓✓ (1)

6.3 $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1,52 \sin\theta_1 = 1,31 \sin 90$

$\sin\theta_1 = 0,86$

$\theta_1 = 59,5°$ ✓ (3)

6.4 $\frac{n_1}{n_2} = 0,86$ Light travels slower in glass✓ (at 86% of the speed that it does in ice) ✓ (2)

7. 7.1 $n_1 \sin\theta_1 = n_2 \sin\theta_2$ (2)

7.2 $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1,00 \checkmark \sin 60° \checkmark = n_2 \sin 21° \checkmark$

$n_2 = 2,41 \checkmark$ (4)

7.3 $n = \frac{c}{v}$

$2,41 \checkmark = \frac{3 \times 10^{8\checkmark}}{v}$

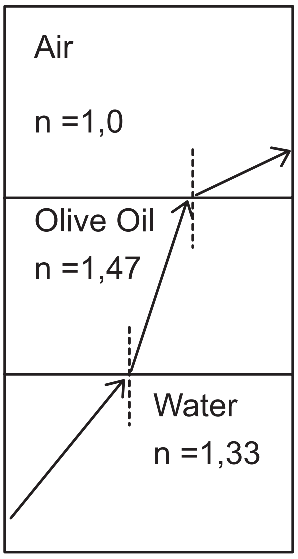
$v = 1,24 \times 10^8 m.s^{-1} \checkmark$ (3)

8. 8.1 The light needs to be in a more optically dense medium ✓ (higher n); the angle of incidence must be greater than the critical angle. ✓ (2)

8.2 The light enters the optical fibre. When the light hits the surface of the core, the angle of incidence is usually greater than the critical angle✓, thus all of the light is reflected back into the core✓. (2)

8.3 Telecommunications/transmissions of large amounts of data✓; endoscopes, ✓ where one set of fibres take light into the body and another set pick up the reflected light and take it back to the doctors (2)

9. 9.1



✓ray bends away from normal ✓ angle of refraction greater than angle of incidence in water.

✓✓ ray bends towards normal

(4)

9.2 Going into the olive oil, the ray slowed down ✓ and bent towards the normal ✓ (2)

TOPIC 5: Geometrical Optics:

GRADE 11: CONSOLIDATION QUESTIONS MEMORANDUM [54 MARKS]

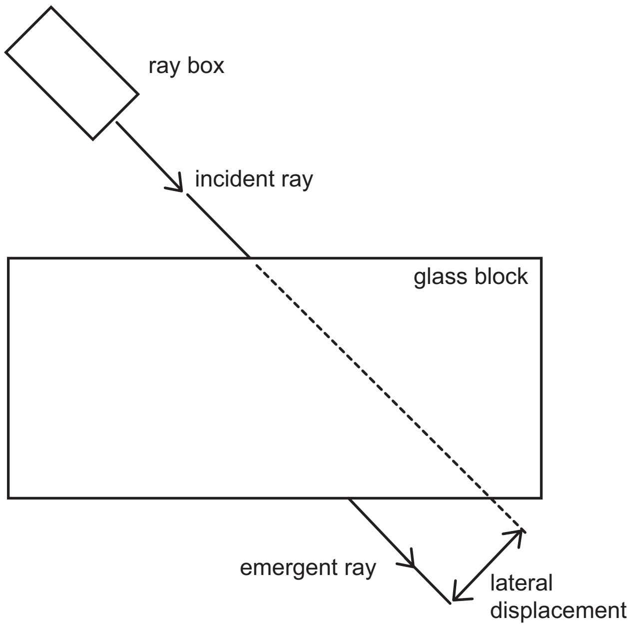
1. C ✓✓ ray does not bend as it travels along the normal (2)

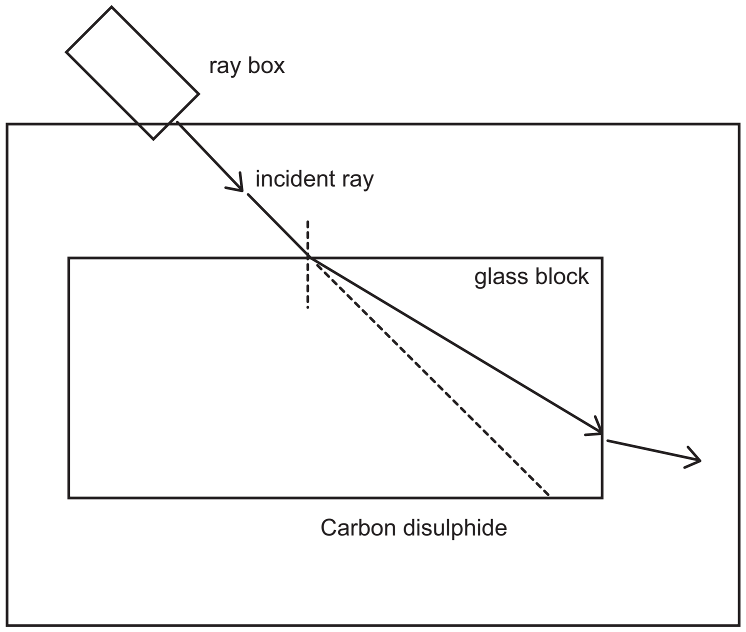
2. A ✓✓ ray refracts away from normal going into a less optically dense medium, at less than the critical angle. (2)

3. a. The ray bends towards the normal as it enters the block. ✓ (1)

   b. Because the sides of the block are parallel✓, the emergent ray will be parallel to the incident ray, the extent that it bends towards the normal✓ when entering the block will be matched by the extent by which it bends away from the normal when exiting the block. (2)

   c. The diagram, the ray ✓✓, normal lines. ✓ (3)





d. Bends away from normal ✓, emergent ray bends towards normal ✓; rest ✓ (3)

4.

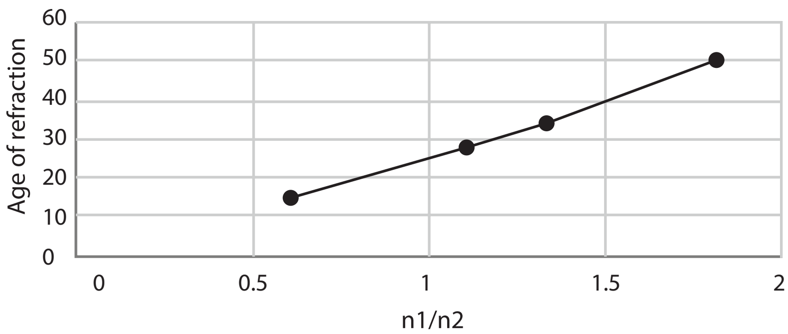
Material 1	Material 2	n_1	n_2	$\frac{n_1}{n_2}$	θ_1	$\sin\theta_1$	θ_2	$\sin\theta_2$	$\frac{\sin\theta_2}{\sin\theta_1}$
water	air	1,33	1,0	**1,33**	25	**0,422**	34,2	**0,56**	**1,33**
75% sugar solution	water	1,47	1,33	**1,1**	25	**0,422**	27,8	**0,47**	**1,1**
diamond	water	2,42	1,33	**1,8**	25	**0,422**	50,3	**0,77**	**1,8**
75% sugar solution	diamond	1,47	2,42	**0,61**	25	**0,422**	14,9	**0,25**	**0,61**

a. Above ✓ each. (4)

b. As $\frac{n_1}{n_2}$ increases, so does θ_2. ✓ ✓ (However this is not a directly proportional.) (2)

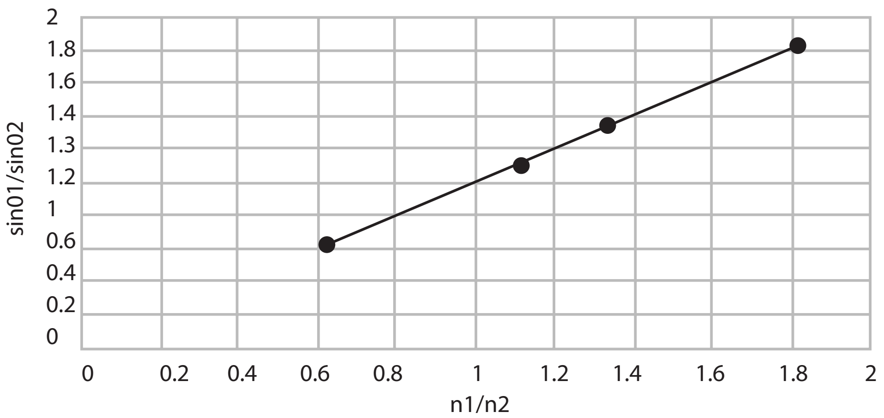
c. ✓ for heading; ✓✓ for points; ✓ for line of best fit (not actually a straight line) (4)

Graph to show the relationship between the ratio of the refractive indices and the angle of refraction



d. See above; ✓✓ for column $\sin\theta_1$; ✓✓ for column $\sin\theta_2$; ✓✓ ✓✓ for column $\frac{\sin\theta_2}{\sin\theta_1}$. (8)

e. ✓ for heading; ✓✓ for points; ✓ for line of best fit. (4)



f. $\frac{n_1}{n_2}$ and $\frac{\sin\theta_2}{\sin\theta_1}$ are directly proportional ✓ ✓ (they are also equal) (2)

g. $\frac{n_1}{n_2}$ = $\frac{\sin\theta_2}{\sin\theta_1}$ is the same as Snell's law $n_1\sin\theta_1 = n_2\sin\theta_2$ ✓✓ (2)

TOPIC 5: Geometrical Optics:

5. a. $n = \frac{c}{v}$

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

$= \frac{3 \times 10^8 ✓}{1,52 ✓}$

$= 1,97 \times 10^8 m.s^{-1}$ ✓ (3)

b. $v = \frac{\Delta x}{t}$

$t = \frac{3000 ✓}{1,97 \times 10^8 ✓}$

$= 0,0000152s$ ✓ (3)

6. 6.1 $n = \frac{c}{v}$

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

$= \frac{3 \times 10^8 ✓}{1,47 ✓}$

$= 2,04 \times 10^8 m.s^{-1}$ (3)

6.2 $n_1 \sin \theta_1 = n_2 \sin \theta_2$

$1,33 \sin 37°$ ✓ $= 1,47 \sin \theta$ ✓

$\sin \theta = \frac{1,33 \sin 37°}{1,47}$

$\sin \theta = 0,544$ ✓ ✓

$\theta = 33°$ ✓ (4)

6.3 The oil is more ✓ optically dense ✓ than the water. (2)

TOPIC 6: 2D and 3D Wavefronts

GRADE 11: WORKSHEET

1. The ability of a wave to spread out as it passes as sharp edge is known as:
   - A Snell's law.
   - B total internal reflection.
   - C diffraction.
   - D Huygens' principle. (2)

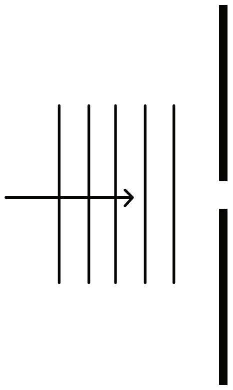
2. The ability of a wave to spread out as it passes as sharp edge is best explained by:
   - A Snell's law.
   - B Newton's third law.
   - C diffraction.
   - D Huygens' principle. (2)

3. Give the name or term for the following:
   - a. The small circular wave that is created by a point on a wavefront. (1)
   - b. When two waves interact with each other in the same space at the same time. (1)
   - c. The bending of a wave as it passes around an obstacle. (1)

4. For the diffraction pattern below, what would you expect to change if:

   - 4.1 The wavelength gets larger (1)
   - 4.2 The wavelength gets smaller (1)
   - 4.3 A larger slit is used (1)
   - 4.4 A smaller slit is used (1)
   - 4.5 The frequency of the wave increases (1)
   - 4.6 The frequency of the wave decreases. (1)

5. In a water ripple tank, the following experiment is set up:

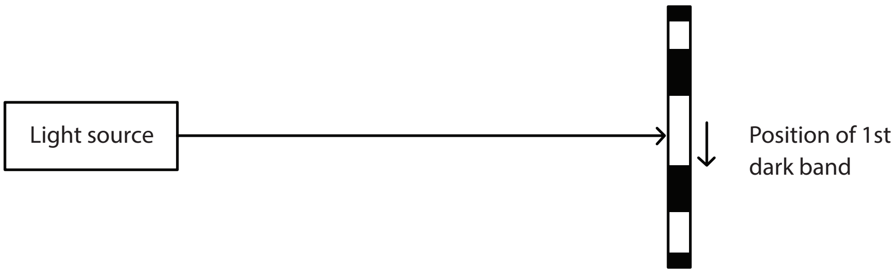


   - 5.1 Complete the diagram to show what happens to the wave as it passes through the slit. (4)
   - 5.2 Name the phenomenon demonstrated in the experiment above. (1)
   - 5.3 Christiaan Huygens explained this effect by what is known as Huygens' principle.

5.3.1 State Huygens' principle. (2)

5.3.2 Explain how this principle explains the phenomenon above. (3)

6. The effect of the width of a slit on the degree of diffraction is examined. Using green light of wavelength 520 nm, they set up an experiment as shown below, and measure the distance of the 1st dark line from the centre of the bright, central band.



The following results are obtained:

Width slit (m)	Position of 1st dark line from the centre
$5,3 \times 10^{-8}$	19,6
$4,9 \times 10^{-8}$	21,2
$4,2 \times 10^{-8}$	24,8

6.1 State Huygens' principle. (2)

6.2 For this experiment give

6.2.1 The dependent variable

6.2.2 The independent variable (2)

6.3 Give the conclusion of this experiment. (2)

GRADE 11: CONSOLIDATION QUESTIONS [43 MARKS]

1. Which of the following will cause the maximum diffraction?
   A Long wavelength, small gap
   B Long wavelength, large gap
   C Short wavelength, small gap
   D Short wavelength, large gap (2)

2. Which property of a sound enables it to undergo diffraction?
   A That it is a **longitudinal** wave.
   B That it is a wave.
   C That is carries energy
   D That it carries sound (2)

3. Consider the diffraction patterns for green light, as shown below.

3.1 What gives rise to the alternating bright and dark areas? (4)

3.2 The two patterns came from green light of identical wavelength. What was done to change the degree of diffraction? (2)

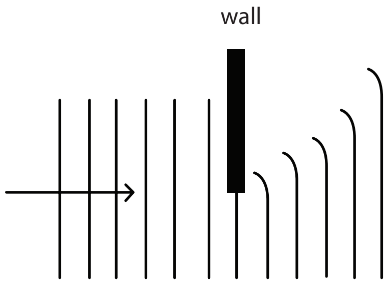
3.3 Explain why there is a broad central band of light that is much wider than either the slit or the incident ray. (2)

3.4 What does this pattern tell you about the nature of the light? (2)

4. 4.1 Define diffraction. (2)

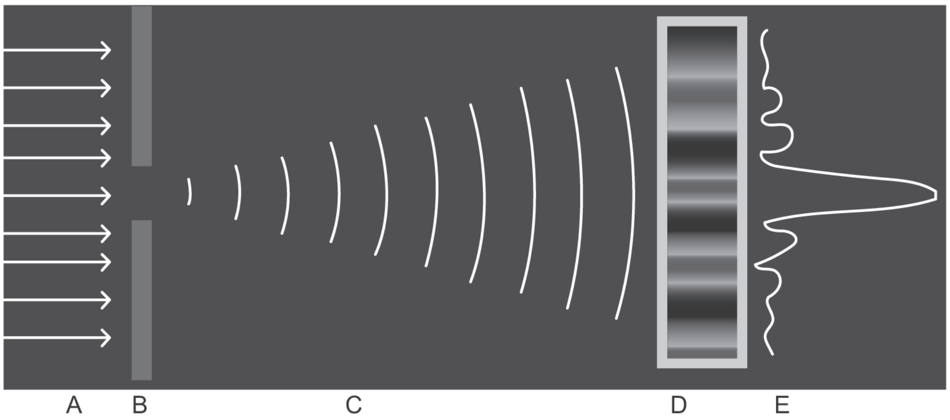
4.2 State Huygen's principle. (2)

4.3 Use these to explain the pattern that is given below. (4)



5. The image below is typical of images found in several text books;

source: http://labman.phys.utk.edu/phys136/modules/m9/diff.htm



In part A waves approach a barrier; Part B is the barrier.

5.1 What is in the barrier that enables the waves to pass through? (1)

5.2 How will the size of this feature affect the waves as they pass through? (2)

5.3 What phenomenon is observed in part C? (1)

5.4 D is a screen. Describe the pattern on the screen. (2)

5.5 Explain how the dark and bright areas on the screen arise. (3)

5.6 Part E is the wave pattern for the wave on the screen. Using the principle of constructive and destructive interference, explain how this wave comes about and how it is related to the bright and dark areas on the screen. (4)

6. Diffraction and interference are regarded as two proofs that something behaves as a wave.

6.1 What is meant by diffraction? (2)

6.2 How did Huygens use interference to explain diffraction? (2)

6.3 Give a practical example of your own where a particle does not undergo:

6.3.1 Diffraction. (2)

6.3.2 Interference. (2)

TOPIC 6: 2D and 3D Wavefronts

GRADE 11: WORKSHEET MEMORANDUM

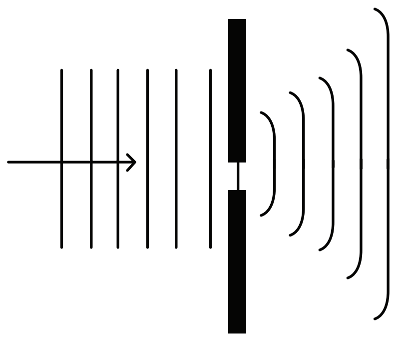
1. C ✓✓ (2)

2. D ✓✓ (2)

3. 3.1 Wavelet ✓ – by definition (1)
   3.2 Superposition or interference ✓ (1)
   3.3 Diffraction ✓ (1)

4. These all use diffraction $\alpha \frac{\lambda}{width}$.
   4.1 The pattern gets wider/shows more diffraction ✓ (1)
   4.2 The pattern is narrower/less diffracted ✓ (1)
   4.3 The pattern is narrower/less diffracted ✓ (1)
   4.4 The pattern gets wider/shows more diffraction ✓ (1)
   4.5 The pattern is narrower/less diffracted ✓ $\lambda = \frac{v}{f}$ so $\lambda\ decreases$ (1)
   4.6 The pattern gets wider/shows more diffraction ✓ $\lambda = \frac{v}{f}$ so $\lambda\ increases$ (1)

5. 5.1



✓ for waves going through ✓ for waves bending at the top ✓; ✓ for waves bending at the bottom; ✓ for overall look of diagram (4)

   5.2 Diffraction ✓ (1)
   5.3 5.3.1 Every point on a wavefront acts as the source of secondary wavelets that spread out in the forward direction with the same speed as the wave. ✓✓ (2)

   5.3.2 Every point on the wavefront is a wavelet. The wavelets destructively interfere with each other except on the wavefront. ✓ However, when the wavefront passes through a slit, the wavelets on each side are removed ✓, which means that the wavelets spread out and cause interference. ✓ (3)

6. 6.1
   6.2 Every point on a wavefront acts as the source of secondary wavelets that spread out in the forward direction with the same speed as the wave. ✓✓ (2)
   6.3 6.3.1 The position of the dark band ✓
   6.3.2 The width of the slit ✓ (2)
   6.4 The degree of diffraction is inversely proportional to the width of the slit ✓✓ (2)

TOPIC 6: 2D and 3D Wavefronts

GRADE 11: WORKSHEET CONSOLIDATION MEMORANDUM [43 MARKS]

1. A ✓✓ the degree of diffraction is proportional to the wavelength and inversely proportional to width (2)

2. B ✓✓ Only waves, but all types of waves undergo diffraction (2)

3. 3.1 The bright bands come from constructive interference ✓✓ and the dark bands from destructive interference. ✓✓ (4)

   3.2 The width of the slit was changed ✓ As diffraction and the 2nd is more diffracted, the width was decreased ✓ (2)

   3.3 The broad central band comes from the wavefront spreading out ✓ as a result of the diffraction ✓ (2)

   3.4 Light has a wave ✓✓ nature. (2)

4. 4.1 Diffraction is the ability of a wave to spread out in wavefronts as they pass through a small aperture or around a sharp edge OR The bending of a wave around an obstacle or the corners of a narrow opening. ✓✓ (2)

   4.2 Every point on a wavefront acts as the source of secondary wavelets that spread out in the forward direction with the same speed as the wave. ✓✓ (2)

   4.3 Every point on the wavefront is a wavelet. The wavelets destructively interfere with each other except on the wavefront. ✓ However, when the wavefront passes an obstruction, the wavelets on the one side are removed ✓, which means that the wavelets spread out on that side ✓ as there is no destructive interference. ✓ (4)

5. 5.1 A slit/gap ✓ (1)

   5.2 Diffraction $\alpha \frac{\lambda}{width}$ A wider slit means less diffraction (or a narrower slit means more diffraction.) ✓✓ (2)

   5.3 Diffraction (1)

   5.4 Alternating bright ✓ and dark bands✓ (2)

   5.5 The bright bands come from constructive interference✓✓ and the dark bands from destructive interference✓ (3)

   5.6 The bright band corresponds to a wave with high amplitude in part E ✓ because there has been lots of constructive interference ✓ resulting in the brighter band. The dark bands correspond to a part of the wave with zero amplitude ✓ due to the destructive interference ✓, resulting in no light (dark.) (4)

6. 6.1 The ability of a wave to spread out in wavefronts as they pass through a small aperture or around a sharp edge ✓✓ OR The bending of a wave around an obstacle or the corners of a narrow opening. (2)

6.2 Every point on the wavefront is a wavelet. The wavelets destructively interfere with each other except on the wavefront.) However, when the wavefront passes an obstruction, the wavelets on the one side are removed ✓, which means that the wavelets spread out on that side as there is no destructive interference. ✓ (2)

6.3 Learners own

6.3.1 e.g.a ball does not diffract when it goes through a doorway etc ✓✓. (2)

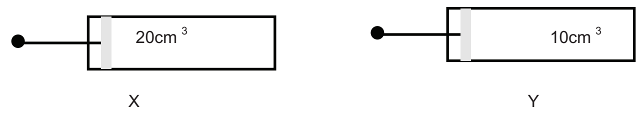
6.3.2 e.g. two balls collide, they bounce off each other, do not pass through & diffract ✓✓. (2)

TOPIC 7: Ideal Gases and Thermal properties

GRADE 11: WORKSHEET

1. A gas is enclosed in a gas syringe. The pressure on the gas is increased, but the temperature of the gas is kept constant. What will happen to the average kinetic energy of the particles?
   A The average kinetic energy will increase.
   B The average kinetic energy will decrease.
   C The average kinetic energy will remain constant.
   D Not enough information is given to answer this question. (2)

2. Two gas syringes, **X** and **Y**, each contains the same gas at STP. The volume of syringe **X** is 20 cm^3 and that of syringe **Y** is 10 cm^3 as shown below.



   Assume ideal gas behaviour.
   Which ONE of the following statements is CORRECT?
   A The average kinetic energy of the molecules in X is less than that of the molecules in Y.
   B The total kinetic energy of the molecules in X is less than that of the molecules in Y.
   C The number of gas molecules in X is equal to the number of gas molecules in Y.
   D There are more gas molecules in X than in Y. (2)

3. Which one of the following is not a property of an ideal gas?
   A The force of attraction between the particles is zero.
   B The molecules make elastic collisions with each other.
   C The product of pressure and volume are constant for a sample of gas at constant temperature.
   D The volume occupied by the gas is equal to the total volume occupied by the molecules. (2)

4. An experiment is conducted to investigate the relationship between the volume and pressure of a gas at **constant temperature**. A 20 cm^3 sample of gas is in a syringe, with a freely moving plunger, at 0˚C and at 100 kPa.
   4.1 What would the volume of the gas be if the pressure was decreased to 75 kPa? (3)
   4.2 Name the law that you used in solving 4.1 above. (1)
   4.3 If both the pressure and the kelvin temperature were doubled, what would the effect be on the volume of the gas sample? (2)

5. During an investigation into the relationship between the volume and the pressure of a given mass of gas at constant temperature (287 K), the following readings were obtained:

Pressure (kPa)	Volume (cm^3)
55	80
85	51,8
110	40
155	28,4
200	22

5.1 What is the relationship between the pressure and volume of a gas? (1)

5.2 Support your answer by using at least **two** sets of readings to show the relationship. (4)

5.3 Why can the volume not be read immediately after the pressure is changed? (2)

5.4 Draw a sketch graph of pressure against volume. (2)

5.5 Draw a sketch graph of pressure and the inverse of volume (1/V). (2)

6. The following relationship holds good for an ideal gas: $PV \propto T$

6.1 Write down what each of the symbols P, V and T represent (3)

6.2 Draw a sketch graph of PV and T. Put T on the vertical (y) axis. (3)

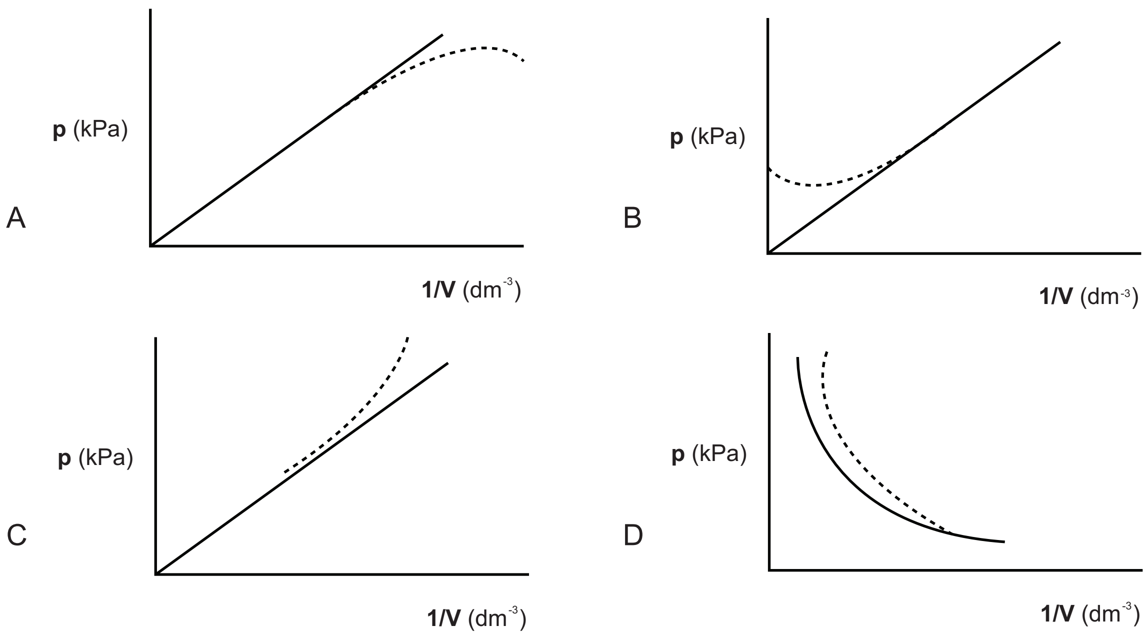
6.3 Under what conditions does the behaviour of a real gas deviate from that of an ideal gas? (2)

6.4 32 g of a gas occupies a volume of 24,1 dm^3 at 112,0 kPa and 51°C. Use this to calculate the molar mass of this gas volume. (5)

GRADE 11: CONSOLIDATION QUESTIONS

1. Which of the following would have behaviour that deviates the most from an ideal gas?
   - A Helium
   - B Hydrogen
   - C Nitrogen
   - D Chlorine (2)

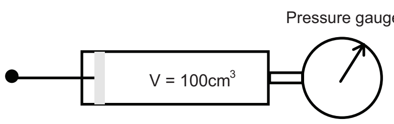
2. In which ONE of the following graphs does the dotted line CORRECTLY represent the deviation of a real gas from ideal gas behaviour?



(2)

3. Consider an ideal gas
   - 3.1 State the ideal gas law in symbols (2)
   - 3.2 Use the ideal gas law to explain the warning that is given an aerosol cans "*do not heat or expose to high temperatures*." (3)
   - 3.3 The pressure on a car tyre is 200 kPa at 27 ˚C. After a fast journey, the temperature increased to 57 ˚C. If the volume of the tyre remains constant, what is the pressure in the tyre at 57 ˚C? (3)

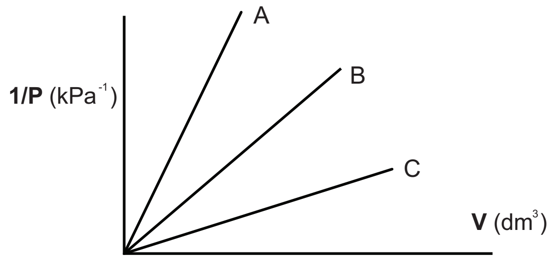
4. A gas syringe is connected to a pressure gauge by means of a short thick tube.



The initial volume of the all the enclosed air is 100 cm^3, and the pressure is 100 kPa.

   - 4.1 What will happen to the reading of the gauge if the plunger is pushed down? (1)
   - 4.2 Calculate the volume of the gas if the pressure is increased to 140 kPa. (3)

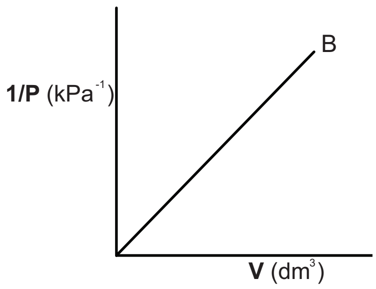
5. The diagram below shows three graphs which were obtained in an investigation of Boyles' law for equal masses of oxygen, helium and neon gases.



5.1 Write down the defining equation for Boyle's law. (2)

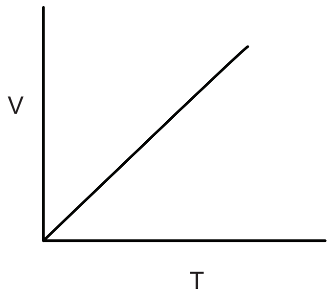
5.2 Which of the graphs (A, B, or C) represent oxygen, which helium and which neon? Give precise reasons for your answers. (6)

5.3



A sketch graph of B only is given. Copy this into your answer sheet. If an equal mass of the same gas was investigated at a lower temperature, sketch, on the same set of axes as **B** the graph that would be obtained. Label this graph **D**. Explain your reasoning. (4)

6. A sketch graph of volume and temperature for an ideal gas is given below.



6.1 Redraw the graph and on the same axes and show what the graph for a real gas would look like. (2)

6.2 Explain the deviation you have shown. (2)

GRADE 11: WORKSHEET MEMORANDUM

1. C – from the definition of temperature, but showing the misconception that pressure is a measure of average E_K. (2)

2. D ✓✓ – this is CL3 because the PV = nRT has not been taught yet, and uses the idea that as a gas expands to fill its container, but with equal pressure at the same temperature, the number of molecules must be larger in the larger container. (2)

3. D ✓✓ – uses misconceptions of the Ideal gas model, which is good for the learners to check their own understanding. (2)

4. $P_1 = 100; V_1 = 20; P_2 = 75; V_2 = ?$ (3)

4.1 $P_1V_1 = P_2V_2$

$$V_2 = \frac{100(20)\checkmark}{75\checkmark} = 26,7cm^3\checkmark$$

4.2 Boyle's law ✓ (1)

4.3 $V_2 = \frac{nRT}{P}$ if both T and P double, then V remains the same ✓✓ (2)

5. 5.1 PV = k ✓ or pressure is inversely proportional to volume etc. (1)

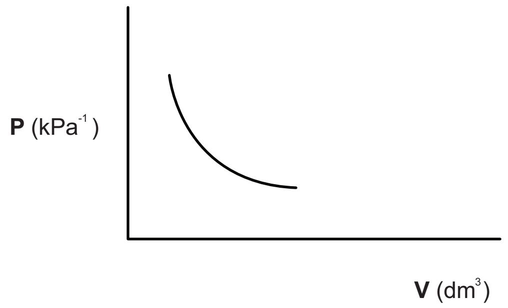
5.2

Pressure (kPa)	Volume (cm^3)	PV
55	80	4400
85	51,8	4403
110	40	4400
155	28,4	4402
200	22	4400

All the PV values are essentially identical. ✓ for each PV value (2 max) and ✓✓ for the conclusion. (4)

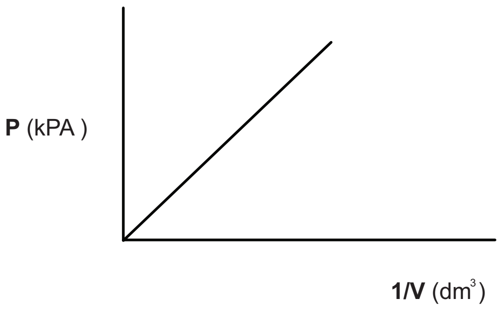
5.3 Because the readings take a few seconds to settle. ✓ ✓ (2)

5.4



✓✓ (2)

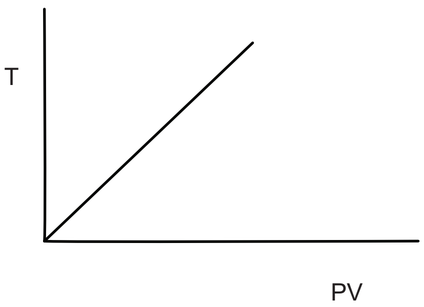
5.5



✓✓ (2)

6. 6.1 P is pressure ✓; V is volume ✓ and T is absolute temperature ✓. (3)

6.2



✓✓ graph shape

✓ axes etc. (3)

6.3 Real gas behaviour deviates at low temperature and high pressure ✓. (2)

6.4 $n = \frac{PV}{RT}$

$= \frac{24,1 \times 10^{-3} ✓ \times 112 \times 10^{3} ✓}{8,31 \times 324 ✓}$

$= 1$

$M = \frac{m}{n}$

$= \frac{32}{1}$ ✓

$= 32 g.mol^{-1}$ ✓ (5)

TOPIC 7: Ideal Gases and Thermal properties

GRADE 11: WORKSHEET CONSOLIDATION MEMORANDUM

1. D ✓✓ – H_2 and He are small with small IMF; N_2 – is bigger, but still small IMF; Cl_2 – is the biggest with the biggest IMF, it has the highest boiling point. (2)

2. C ✓✓ – real gases deviate under high pressure (so only A or C); the P > expected due to the size of the molecules. (2)

3. 3.1 PV = nRT ✓✓ (2)

   3.2 When temperature is high ✓, the pressure inside the can will be high ✓ (P α T) and V is fixed ✓. The pressure becomes so high that the can may explode. (3)

   3.3 $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

   $P_2 = \frac{200}{300} \checkmark \times 350 \checkmark$

   = 233 kPa✓ (3)

4. 4.1 It will increase ✓ (1)

   4.2 $P_1V_1 = P_2V_2$

   $V_2 = \frac{100 \times 100 \checkmark}{140 \checkmark}$

   $= 74,1cm^3 \checkmark$ (3)

5. 5.1 $PV = k \checkmark\checkmark \ (OR\ P_1V_1 = P_2V_2)$ (2)

   5.2 All the gases have equal masses

   n = m/M; and M_{He} = 4; M_{Ne} = 20; M_{O2} = 32; so $n_{He} > n_{Ne} > n_{O2}$ ✓

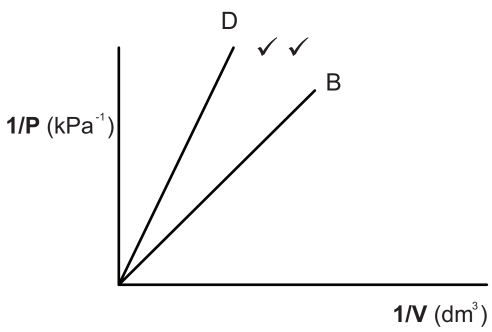
   so $PV_{He} > PV_{Ne} > pV_{O2}$ ✓

   PV = nRT; $\frac{1}{P} = \frac{V}{nRT}\ or\ \frac{1}{P} = \frac{1}{nRT}(v)$

   This means the greater n is, the smaller the slope ✓ of the 1/P vs V graph

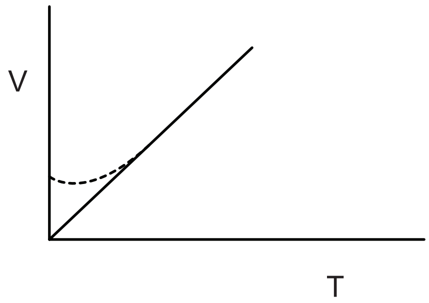
   So **A** is O_2 ✓; **B** is Ne ✓; **C** is He ✓ (6)

   5.3



   $\frac{1}{P} = \frac{1}{nRT} \checkmark (V)$ so a lower T implies a greater slope ✓ of the graph. (4)

6. 6.1



✓✓ graph shape (2)

6.2 At very low temperatures, the volume of the gas is greater ✓ than expected due to the size of the molecules being significant. ✓ (2)

TOPIC 8: Quantitative Aspects of Chemical Change

GRADE 11 WORKSHEET

1. How many moles of chloride ions are present in 111 g of calcium chloride?

   A 0,5 B 2

   C 1 D 1,47 (2)

2. What amount of oxygen gas (in moles) contains 1,8 x 10^{22} molecules?

   A 0,03 B 33,34

   C 1,2 x 10^{24} D 1,08 x 10^{46} (2)

3. Which of the following is true for a standard solution? In a standard solution the…

   A concentration is always known

   B concentration is always 1 $mol.dm^{-3}$

   C temperature is always 0°C

   D pH is always 7 (2)

4. Coal burns in oxygen to produce energy, according to the following equation:

   $C(s) + O_2(g) \rightarrow CO_2(g)$

   4.1 If coal reacts with 9 000 000 000 m^3 of oxygen, what volume of carbon dioxide will be produced? (2)

   4.2 In addition to your answer give an important science idea that you use to deduce the answer. (2)

5. 

   P: n = 0,2 mol Q: c = 0,5 $mol.dm^{-3}$

   V = 0,3 dm^3 V = 0,2 dm^3

   Beaker P contains 0,2 mol NaCl dissolved in 0,3 dm^3 of water. Beaker Q contains 0,2 dm^3 of NaCl solution with a concentration of 0,5 $mol.dm^{-3}$. If the content of beaker P is added to the content of beaker Q, the concentration of the mixture will be …

   A 1,17 $mol.dm^{-3}$

   B 0,67 $mol.dm^{-3}$

   C 0,60 $mol.dm^{-3}$

   D 0,58 $mol.dm^{-3}$ (2)

6. The Haber process is used to form ammonia according to the equation:

   $N_2(g)$ + $3H_2(g)$ $2NH_3(g)$.

   At STP, 30 m^3 of ammonia is formed;

   6.1 What does "STP" stand for? (2)

   6.2 Give the values for STP. (2)

6.3 What volume of nitrogen was reacted? (2)

6.4 What volume of hydrogen was reacted? (2)

7. During a titration, 20 cm^3 of a 0,1 $mol \cdot dm^{-3}$ nitric acid solution neutralises 25 cm^3 of the above standard solution according to the following balanced equation:

$$2HNO_3(aq) + Na_2CO_3(aq) \rightarrow 2NaNO_3(aq) + H_2O(\ell) + CO_2(g)$$

7.1 Write down the NAME of the salt formed in the above reaction. (1)

7.2 Calculate the mass of sodium carbonate used to prepare the standard solution in the volumetric flask. (5)

8. Calcium carbide reacts with water to produce ethyne and calcium hydroxide according to the following equation:

$$CaC_2(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + C_2H_2(g)$$

8.1 15,0 dm^3 of ethyne gas is produced at S.T.P. How many moles of gas are produced? (2)

8.2 49,15 g of calcium carbide was used to produce the gas. What is the percentage purity of the reactant? (4)

8.3 On Wednesday 12 August 2015 a series of explosions that killed over one hundred people and injured hundreds of others occurred at container storage station at the Port of Tianjin in China. A fire had broken out at a warehouse, and the first people on the scene couldn't keep the fire from spreading. Firefighters then arrived and tried to douse the fire with water as they were unaware that dangerous chemicals, including calcium carbide, were stored on the site, and so they set in motion a series of more violent chemical reactions. The first full explosion occurred soon after and registered as a magnitude 2,3 earthquake, generating shock-waves equivalent to 3 tons of TNT. Shortly after, a second more powerful explosion, equivalent to 21 tons TNT occurred, causing most of the damage and injuries with shock-waves felt many kilometres away. The resulting fireballs reached heights of hundreds of meters.

Adapted from Wikipedia https://en.wikipedia.org/wiki/2015_Tianjin_explosions; accessed 22 Feb 2016

8.3.1 Why should "dry" firefighting methods have been used? (2)

8.3.2 Give the balanced reaction equation for C_2H_2 burning to produce carbon dioxide and water. (3)

8.3.3 One ton of calcium carbide can produce 15 625 mol of C_2H_2. Calculate the mass of CO_2 produced from one ton of calcium carbide. (3)

TOPIC 8: Quantitative Aspects of Chemical Change

GRADE 11 WORKSHEET CONSOLIDATION [33 MARKS]

1. Which of these samples contains the same number of atoms as 1 gram of H_2?
   A. 22 g of carbon dioxide, CO_2
   B. 8 g of methane, CH_4
   C. 20 g of neon, Ne
   D. 8 g of ozone, O_3 (2)

2. 160 cm^3 of a 1,5 $mol.dm^{-3}$ nitric acid solution reacts with 15 g of calcium carbonate, according to the following balanced reaction:

   $$2HNO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$$

   2.1 Identify the limiting reactant. (5)

   2.2 What mass of water is produced? (4)

3. It is found that 40 cm^3 of a 0,5 $mol.dm^{-3}$ sodium hydroxide solution is needed to neutralise 20 cm^3 of the vinegar with a mass of 20,8 g. Vinegar is a solution of ethanoic acid in water.

   3.1 Calculate the number of moles of sodium hydroxide that reacted. (2)

   3.2 Calculate the mass of ethanoic acid present in the vinegar. (3)

   3.3 Calculate the percentage (by mass) of ethanoic acid present in the vinegar. (2)

4. Consider the following balanced chemical reaction:

   $$2HNO_3 (aq) + Ca(OH)_2 (aq) \rightarrow Ca(NO_3)_2 (aq) + 2H_2O (l)$$

   25,0 ml of the nitric acid of concentration of 0,15 $mol.dm^{-3}$ reacts with the calcium hydroxide solution.

   4.1 How many moles of acid are used? (2)

   4.2 What mass of calcium hydroxide reacted with the nitric acid? (3)

   4.3 13,6 ml of calcium hydroxide solution was used. What was the concentration of the calcium hydroxide solution? (2)

5. A protein is found to be 18.39% oxygen, 31,18% nitrogen, 41,38% carbon and 8,05% hydrogen.

   5.1 Determine its empirical formula. (6)

   5.2 The molar mass of the protein is 174,0 $g.mol^{-1}$. What is its molecular formula? (2)

TOPIC 8: Quantitative Aspects of Chemical Change

GRADE 11: WORKSHEET MEMORANDUM

1. C ✓✓ M = 40,1 + (35,45)2 = 111,1; $n = \frac{m}{M}$ (2)

2. A ✓✓ $n = \frac{N}{6,02 \times 10^{23}} = 0.03$ (2)

3. A ✓✓ by definition (2)

4. 4.1 9 000 000 000 m^3 ✓✓of CO_2(g) is produced (2)
   4.2 Science idea: The balanced equation for the reaction equation gives the mole ratio of O_2(g) : CO_2(g) is 1 : 1, which is the ratio of the volumes of the gases. ✓✓ (2)

5. C ✓✓ $c = \frac{n}{V} = \frac{(0,2)+(cV)}{0,2+0,3} = \frac{(0,2)+(0,1)}{0,5} = 0,6 mol.dm^{-3}$ (2)

6. 6.1 Standard temperature and pressure. ✓ ✓ (2)
   6.2 0 K ✓ and 101,3 kPa ✓ (2)
   6.3 15 m^3 ✓ ✓ (mole & volume ratio is 1:2) (2)
   6.4 45 m^3 ✓ ✓ (mole & volume ratio is 3:2) (2)

7. 7.1 sodium nitrate ✓ (1)
   7.2 $n_{HNO_3} = cV = 0,02 \times 0,1$ ✓ $= 0,002 mol$ ✓

   $n_{Na_2CO_3} = 0,001 mol$ ✓ $(from\ ratios)\ in\ 25 cm^3$

   $n_{Na_2CO_3} = 0,01$ ✓ $mol\ \ in\ 250 cm^3$

   $m = nM = 0,01(23 \times 2 + 12 + 16 \times 3) = 1,06 g$ ✓ (5)

8. $CaC_2(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + C_2H_2(g)$

   8.1.1 $n = \frac{V}{22,4} = \frac{15,0}{22,4}$ ✓ $= 0,67 mol$ (-1 no unit) (2)

   8.1.2 CaC_2 : C_2H_2

   1 mol : 1 mol

   $n_{CaC_2} = 0,67 mol$ ✓ OR 49,15 g → 0,768 mol

   $m = n.M = 0,67 \times 64$ ✓ $= 42,88 g$ ✓ % purity = 0,67/0,768 = 87,24%

   $\% \ purity = \frac{42,88}{49,15} \times 100 = 87,24\%$ ✓ ✓ (4)

   8.2.1 Because CaC_2 reacts with water ✓ to produce a flammable gas. ✓ (2)

   8.2.2 $2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$ ✓ left ✓ right ✓balancing (3)

   8.2.3 C_2H_2 : CO_2

   1 mol : 2 mol

   15 625 mol : 31 250 mol ✓

   $m = n.M = 31250 \times 44$ ✓ $= 1\,375\,000 g$ ✓ (i.e. 1,375 tonnes) (3)

TOPIC 8: Quantitative Aspects of Chemical Change

GRADE 11: WORKSHEET CONSOLIDATION MEMORANDUM [33 MARKS]

1. C✓✓ $n_H = \frac{1}{1} = 1\,mol\ \ atoms$; (aA = $\frac{1}{2}$ mol; B = $\frac{1}{2}$ mol; D = 0,167 mol) (2)

2. 2.1 $2HNO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$

$n_{(HNO3)}$ = CV = (1,5)(0,16) ✓ = 0,24mol ✓	$n_{(CaCO3)} = \frac{15}{40+12+48}$ $= \frac{15}{100}$ = 0,15mol ✓

2:1 ratio. ✓ Therefore, <u>HNO_3</u> is the limiting reactant. ✓ (5)

2.2 0,24mol ÷ 2 ✓ = 0,12mol ✓

$n_{(H2O)} = \frac{m}{18}$ C.A.

$\therefore 0,12 = \frac{m}{18}$ ✓ ∴ m = <u>2,16</u> g ✓ (4)

3. 3.1 n(NaOH) = cV
= (0,5)(0,04) ✓
= 0,02 mol ✓ (2)

3.2 $n(CH_3COOH)$ = n(NaOH)
= <u>0,02 mol</u> ✓
∴ $m(CH_3COOH)$ = n.Mr
= (0,02)(60) ✓
= <u>1,2 g</u> ✓ (3)

3.3 % mass of CH_3COOH = 1,2 / 20,8 x 100 ✓
= <u>5,77 %</u> ✓ (2)

4. 4.1 $n_a = c_a.V_a = (0,15).(0,025\checkmark) = 0,00375\,mol\checkmark$ (2)

4.2 HNO_3 : $Ca(OH)_2$
2 mol : 1 mol
0,00375 : 0,001875 mol✓
$m = n.M = (0,001875).(74\checkmark) = 0,14g\checkmark$ (3)

4.3 $c_b = \frac{n_b}{V_b} = \frac{0,001875}{0,0136\checkmark} = 0,14 mol.dm^{-3}\checkmark$ (2)

5. 5.1 $n_O = \frac{18,39}{16} = 1,15\ mol$ ✓

$n_N = \frac{32,18}{14} = 1,30\ mol$ ✓

$n_C = \frac{41,38}{12} = 3,45\ mol$ ✓

$n_H = \frac{8,05}{1} = 8,05\ mol$ ✓

Ratio	O	:	N	:	C	:	H	
	1,15	:	2,30	:	3,45	:	8,05	
	1	:	2	:	3	:	7	✓

So empirical formula is $C_3H_7ON_2$ ✓ (6)

5.2 $M_{C3H7ON2} = 87,0\ g.mol^{-1}$ ✓; $M_{actual} = 174 = 2 \times 87$

Molecular formula is $C_6H_{14}O_2N_6$ ✓ (2)