Catholic Junior College
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME	
CLASS	2T

PHYSICS
9749/2

Paper 2: Structured Questions

25 August 2022

2 hours

READ THESE INSTRUCTIONS FIRST
Write your name and class on all the work you hand in.
Write in dark blue or black pen in the space provided. **[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]**
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use highlighters, glue or correction fluid.

Answer all questions in Paper 2.

Suggested Solutions

FOR EXAMINER'S USE		DIFFICULTY		
		L1	L2	L3
Q1	/ 11			
Q2	/ 8			
Q3	/ 11			
Q4	/ 9			
Q5	/ 7			
Q6	/ 5			
Q7	/ 7			
Q8	/ 22			
PAPER 2	/ 80			

PHYSICS DATA:

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_P	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} mol^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

PHYSICS FORMULAE:

uniformly accelerated motion	s	=	$u t + \frac{1}{2} a t^2$
	v^2	=	$u^2 + 2 a s$
work done on / by a gas	W	=	$p \Delta V$
hydrostatic pressure	P	=	$\rho g h$
gravitational potential	ϕ	=	$-\frac{Gm}{r}$
temperature	T / K	=	$T / {}^{\circ}C + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm \omega \sqrt{x_0^{\,2} - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** questions from this paper.

1 A cliff train cabin is used to carry passengers up a slope as shown in Fig.1.1.

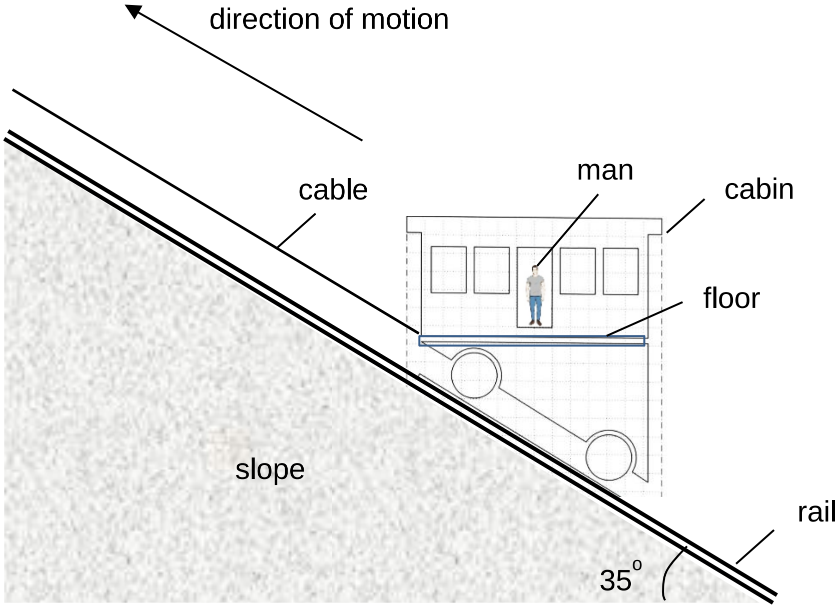


Fig. 1.1

The cable attached to the cabin pulls the cabin up the slope along the rail line which is inclined at 35° to the horizontal.

Initially, the cabin starts from rest and accelerates at 1.0 m s^{-2} for a time of 3.0 s. The cabin then moves at constant speed of 3.0 m s^{-1} for 100 s. Finally, the cabin decelerates to rest in 3.0 s.

The floor of the cabin is horizontal all the times. A man of mass 95 kg is standing upright on the floor of the cabin.

(a) Calculate the vertical height moved by the man during the initial acceleration of the cabin.

height = …………….……………….. m [3]

Distance moved **along the rail line**,

$$s = (0)(3.0) + \frac{1}{2}(1.0)(3.0)^2 = 4.5\ m$$ **1**

Vertical height moved,

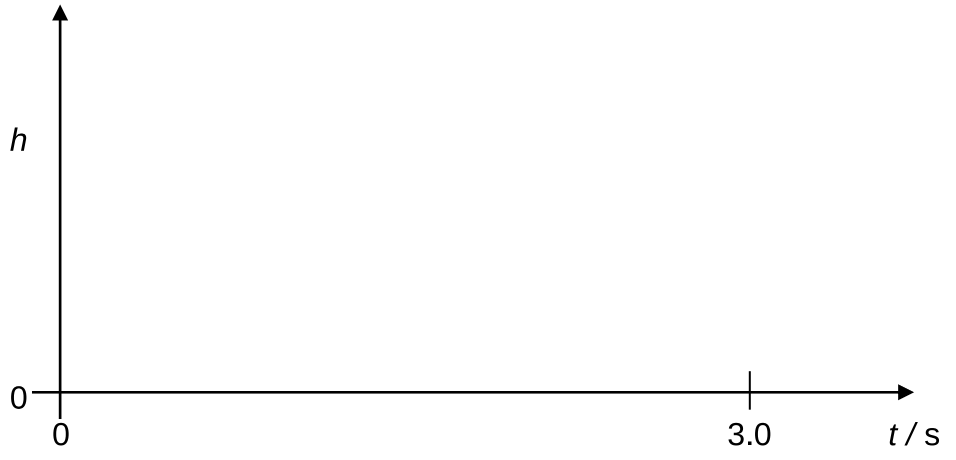
$h = s\sin(35°)$ **1**

$h = (4.5)(sin35°) = 2.58109 = \mathbf{2.6\ m}$ **1**

	(b)	**(i)**	Calculate the normal reaction force acting on the man from the floor of the cabin when the cabin is moving at constant speed.	
			normal reaction = ……………………………. N	[1]
		N = W = mg = $95 \times 9.81 = 931.95 = \mathbf{930\ N}$		**1**
		(ii)	Explain your working in **(i)**.	
			………………………………………………………………………………………..………..	
			………………………………………………………………………………………..	[1]
		At constant speed, there is no acceleration, hence there is no net force acting on the man. There are two forces acting on the man: his weight and the normal reaction force of the floor on the man. Since the weight acts vertically down, the normal reaction force must be equal in magnitude and opposite in direction to the weight to produce a zero net force.		**1**
	(c)	Forces act on the man by the floor of the cabin.		
		(i)	State the forces for the man as the cabin accelerates.	
			……………………………………………………………………………..……………..	[1]
		Frictional force and **normal contact force** by the floor, and, man's **weight.**		**1**
		(ii)	Explain how these forces produce the acceleration of the man.	
			………………………………………………………………………………………..……….....	
			………………………………………………………………………………………..	[2]
		The **vector sum** of the frictional force, the normal contact force and the man's weight is **non-zero** and **acts along the direction of the motion of the cabin**. OR **Normal contact force is greater than man's weight,** causing a resultant force vertically upwards. The **resultant** of the **horizontal leftwards acting frictional force and the resultant vertical force acts along the direction of the motion** of the cabin to produce acceleration.		**1** **1** **1** **1**

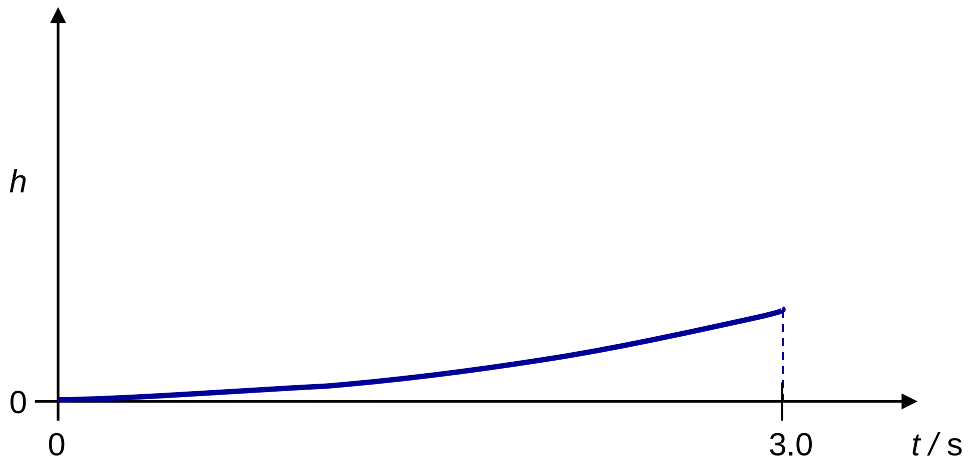
(d) The vertical height *h* of the man varies with time *t*. On the axes below, show qualitatively the variation with time *t* of height *h* for the motion of the man during

(i) the acceleration,



[1]

Solution:

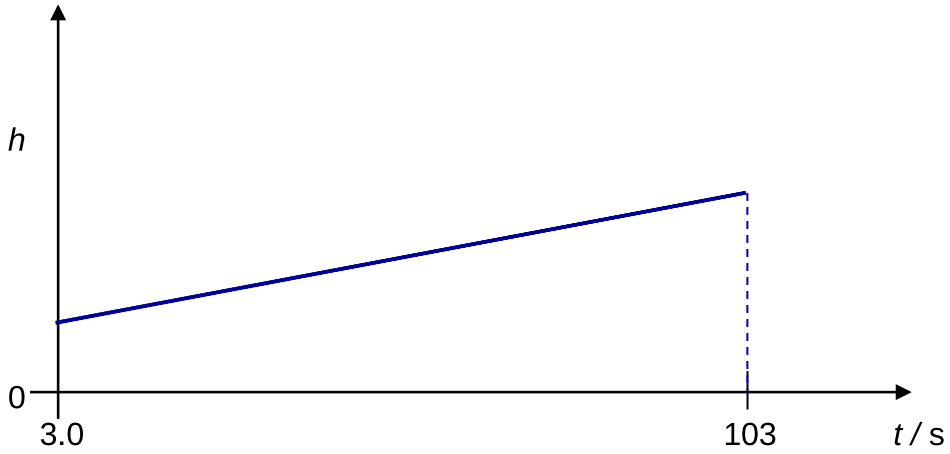


1

(ii) the constant speed,

[1]

Solution:

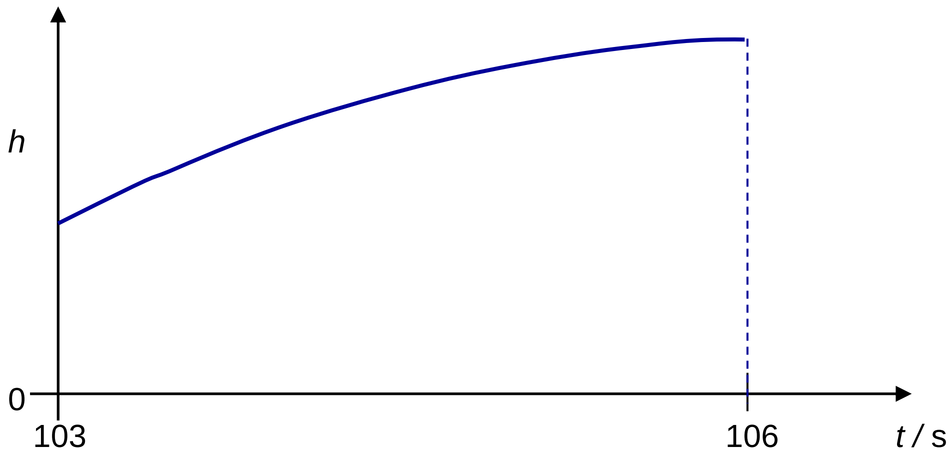


1

(iii) the deceleration.

[1]

Solution:



1

2	A stationary electron is in a uniform field of force.			
	(a)	Describe the direction of the force on the electron relative to the direction of the field if the field is		
		(i)	a gravitational field,	
			…………………………………………………………………………………………..	[1]
			same direction of the field.	**1**
		(ii)	an electric field,	
			…………………………………………………………………………………………..	[1]
			opposite direction to the field.	**1**
		(iii)	a magnetic field.	
			…………………………………………………………………………………………..	[1]
			no force acts.	**1**
	(b)	Describe and explain the path the electron will take when it moves at right angles to each field.		
		…………………………………………………………………………………………………..		
		…………………………………………………………………………………………………..		
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		…………………………………………………………………………………………………..		
		…………………………………………………………………………………………………..		[5]
		For gravitational field and electric field, the electron will move in a **parabolic path**, as the ***net* force (or acceleration) is *always* of *constant* direction and *constant* magnitude throughout the motion** despite the direction of the electron's velocity. **For magnetic field,** when the electron moves at right angle to the magnetic field, it **experiences a magnetic force that is *always* acting *perpendicular* to the velocity** of the electron. This **changes the direction of the velocity of the electron continuously, but not the magnitude of velocity.**			**1** **1** **1** **1**

		This **constant speed will keep the magnetic force and hence the centripetal force constant in magnitude**, causing the electron to move in a **circular path of constant radius**.	**1**

3	**(a)**	**(i)**	Explain what is meant by an *ideal gas*.	
			…………………………………………………………………………………………………	
			………………………………………………………………………………………………	[2]
			An ideal gas is one that obeys the ideal gas equation pV = nRT at all values of temperature (T), pressure (p) and volume (V), where n is the number of moles of gas and R is the molar gas constant.	**1** **1**
		(ii)	Use the kinetic theory of gases to explain why when the volume of an ideal gas decreases at constant temperature, the pressure of the gas increases.	
			…………………………………………………………………………………………………	
			…………………………………………………………………………………………………	
			…………………………………………………………………………………………………	
			…………………………………………………………………………………………………	
			…………………………………………………………………………………………………	
			…………………………………………………………………………………………………	
			………………………………………………………………………………………………	[4]
			When temperature is constant, the root-mean-square speed of the gas atoms is constant. Therefore, **when volume decreases,** the distance travelled by the atoms between successive collisions with a wall of the container decreases, leading to a **higher frequency of collisions between the gas atoms and the wall of the container**. A **higher frequency of collisions leads to greater total rate of change of momentum of all the molecules hitting a wall** at any instant in time and **thus larger force on the container**, thus a higher pressure.	**1** **1** **1** **1**

(b) A fixed amount of an ideal gas undergoes a cycle of changes A→B→C→A as shown in Fig. 3.1.

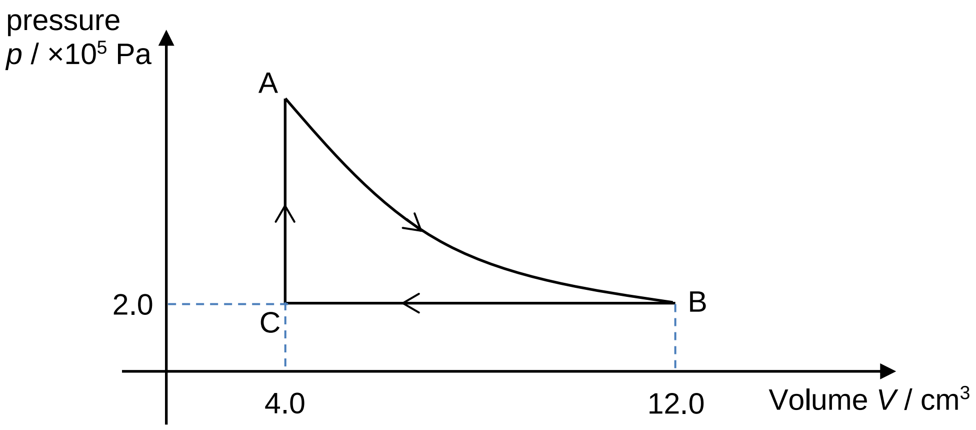


Fig. 3.1

(i) Determine the work done on the ideal gas during the process B→C.

work done on gas = ... J [2]

$W = -p\Delta V$

$W = -(2.0\times10^{5})(4.0-12.0)(10^{-6})$ **1**

$W = 1.6\ \text{J}$ **1**

(ii) Explain why there is a net thermal energy absorbed by the ideal gas when it undergoes a cycle of changes A→B→C→A.

....

....

....

....

....

....

.... [3]

Per cycle, **total** work done **by** gas is **greater** than **total** work done **on** the gas, thus there is a **net** work done **by** gas. **1**

Per cycle, there is **no net** change in the internal energy of the ideal gas. **1**

1

			Thus, by the First Law of Thermodynamics, $\Delta U = Q + W$, with a **net** work done **by** the gas, there needs to be a **net** thermal energy **supplied to** the gas so that there is **no net change in** the internal energy.	

4 The variation with potential difference *V of* current I in a resistor X is shown in Fig. 4.1.

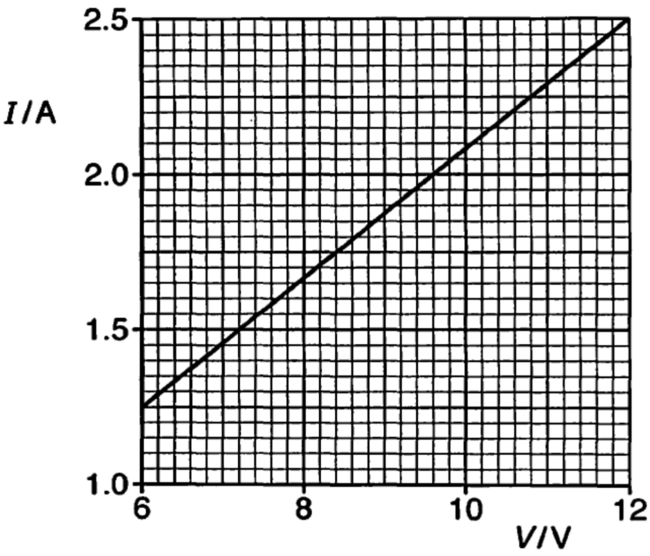


Fig. 4.1

(a) Use Fig. 4.1 to show that the resistance of X remains constant.

[2]

Method:

- *calculate the RATIO of the V-coordinate to the I-coordinate.*
- *Compare the ratios from the different points. Show that the ratios are constant.*

At (6.0 V, 1.25 A), $R = \frac{V}{I} = \frac{6.0}{1.25} = 4.8\ \Omega$ **1**

At (12 V, 2.5 A), $R = \frac{V}{I} = \frac{12}{2.5} = 4.8\ \Omega$

Since the ratio $\frac{V}{I}$ remains constant at 4.8 Ω, resistance of X remains constant. **1**

Method 2:

- Calculate gradient with either 2 points that are far apart on the graph OR at least 3 different points along the graph. **1**
- Use the gradient and straight line equation to calculate y-intercept and show that it is equal to zero. **1**

(b) In an attempt to obtain the graph of Fig. 4.1 for resistor X, a student sets up a circuit as shown in Fig. 4.2.

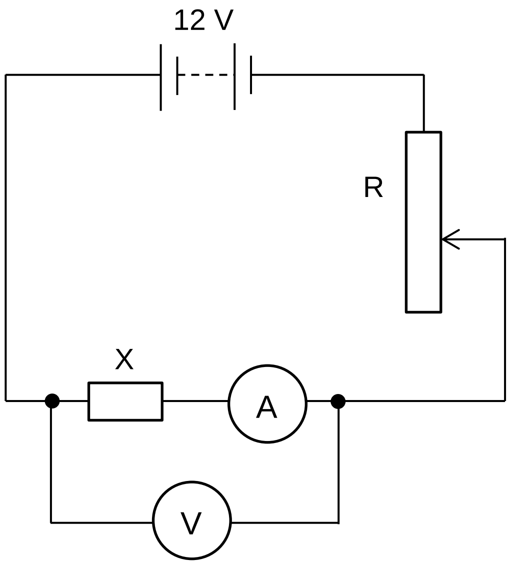


Fig. 4.2

The battery has an e.m.f. of 12 V and negligible internal resistance. The resistor R has a resistance that can be varied between 0.0 Ω and 2.0 Ω. The voltmeter and ammeter are both ideal.

State and explain why the circuit shown in Fig. 4.2 is inappropriate for obtaining data from V = 6 V to V = 12 V for the graph in Fig. 4.1.

....

....

....

....

.... [2]

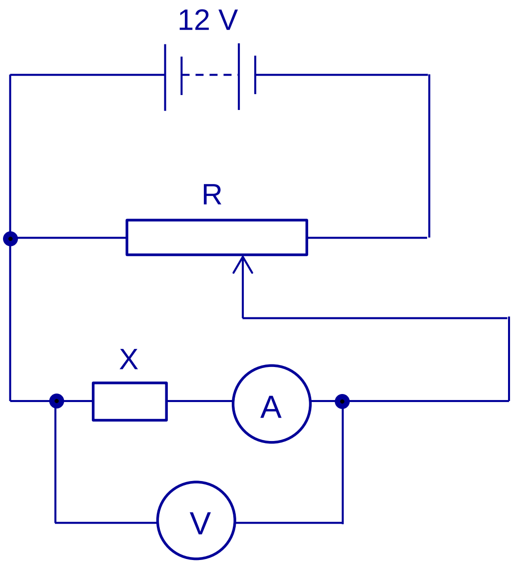
When R is set to its minimum of 0 Ω, a maximum potential difference (p.d.) of 12 V can be applied across X. Hence voltmeter and ammeter readings up to V = 12 V are obtainable. **1**

However, when R is set to its maximum of 2.0 Ω, since X has resistance of 4.8 Ω which is greater than 2.0 Ω, the p.d. across X will be greater than 6 V ($\frac{4.8}{4.8+2.0} x12 = 8.5\ V$). It would thus be impossible to obtain voltmeter and ammeter readings in the range of V = 6 V to V = 8.5 V in Fig. 4.1. **1**

(c) In the space below, draw a circuit diagram using the same components as shown in Fig. 4.2 from which the graph of Fig. 4.1 may be determined.

[1]

Solution:

			1
	(d)	Calculate the difference in the power dissipated in resistor X when *V* is increased from 7.2 V to 9.6 V.	
		difference in power = ... W	[2]
		Solution: $Difference\ in\ power = I_1V_1 - I_2V_2$ $= (2.0)(9.6) - (1.5)(7.2)$ $= 8.4\ W$	**1** **1**
	(e)	Suppose the battery has an internal resistance of 0.50 Ω, and R in Fig. 4.2 is adjusted to 0 Ω. Calculate the terminal potential difference across the battery.	
		terminal potential difference = ... V	[2]
		By potential divider principle, $terminal\ p.d. = p.d. across\ X = \frac{4.8}{4.8 + 0.5}\ x\ 12\ V$ = 10.868 V = **11 V**	**1** **1**

5	**(a)**	When white light is incident on a single slit, a diffraction pattern is formed on a screen. The central fringe of the diffraction pattern is coloured at the edges and has a white central region. Explain this observation.		
		……………………………………………………………………………………………………		
		……………………………………………………………………………………………………		
		……………………………………………………………………………………………………		[2]
		White light consists of <u>all</u> colours of visible light, which is of a <u>continuous range of wavelengths</u>. The <u>longer the wavelength</u>, the <u>greater the degree of diffraction</u>, <u>producing a central fringe of larger width</u>.		**1**
		In the central region where <u>all</u> colours <u>overlap</u>, it is white. **At the edges where not all colours are present, they are coloured.**		**1**
				
		OR White light consists of visible light of a continuous range of wavelengths. **Visible light of every wavelength meet with zero path difference at the centre, (thus meet in phase and undergo constructive interference,) thus all the overlapping colours produces a white region.** **At the edges, there are destructive interference of some light but not for others as the extent of diffraction increases with the wavelength. Hence the edges would not be white but be of the mixed colour of wavelengths that have non-zero intensity.**		
	(b)	**(i)**	Explain what is meant by the *Rayleigh criterion* for the resolution of the images of two objects.	
			……………………………………………………………………………………………	
			……………………………………………………………………………………………	
			……………………………………………………………………………………………	[2]
			Two objects will be ***<u>just</u>* <u>seen as separate / *just* distinguishable</u>** when the **<u>first minimum</u> in the <u>diffraction pattern</u> of one image <u>coincides with</u>** the **<u>central maximum of the other</u>**. □	**1** **1**

		(ii)	The Griffith Observatory in Los Angeles includes an astronomical refracting telescope (Griffith telescope) with an objective lens of diameter 0.305 m. Calculate the wavelength of light for which the Griffith telescope has a minimum angular resolution of 1.8×10^{-6} rad.	
			wavelength = ... m	[1]
			From Rayleigh Criterion, $\theta_{min} \approx \frac{\lambda}{b}$ $1.8\ x\ 10^{-6} \approx \frac{\lambda}{0.305}$ $\lambda\ \approx 5.49\ x\ 10^{-7} =\ \mathbf{5.5\ x\ 10^{-7}\ m}$	1
		(iii)	The asteroid Apophis has a diameter of 325 m. It has been calculated that in the year 2029, its distance of closest approach to the Earth's surface will be 3.0×10^4 km. Supporting your answer with calculations, explain whether the Griffith telescope can resolve Apophis.	
			....	
			....	[2]
			Angular size of asteroid, $\boldsymbol{\theta} \approx \frac{\mathbf{325}}{\mathbf{3.0\ x\ 10^4 x\ 10^3}}$ $= \mathbf{1.0833\ x\ 10^{-5} = 1.1\ x\ 10^{-5} rad}$ **As $\mathbf{1.1\ x\ 10^{-5} rad}$ is greater than $\mathbf{1.8\ x\ 10^{-6}\ rad}$, the angular size of the asteroid exceeds the minimum angular resolution of the Griffith telescope, thus the telescope can resolve the asteroid.**	1 1

6	In an X-ray tube, electrons are produced from a filament heated by an electric current as shown in Fig. 6.1. A large accelerating potential difference is set up between the filament and the target material. The electrons are accelerated from the filament and hit the target material to emit X-ray photons.		

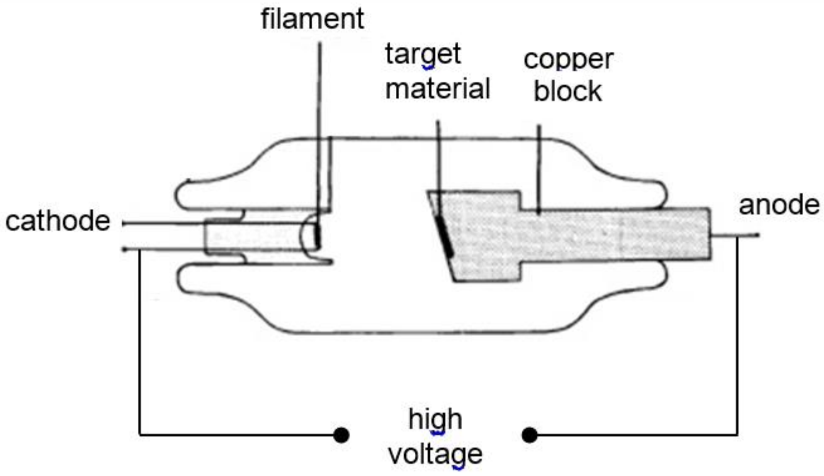


Fig. 6.1

A graph of intensity against wavelength of the emitted radiation is plotted as shown in Fig. 6.2 when the X-ray tube is operated at a voltage of 50 kV.

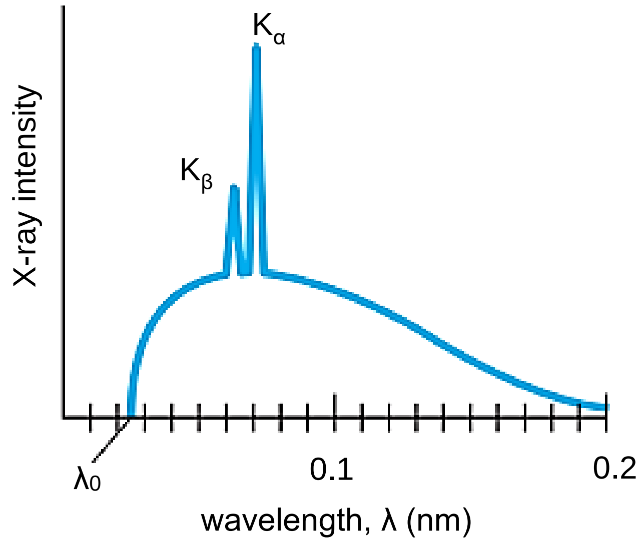
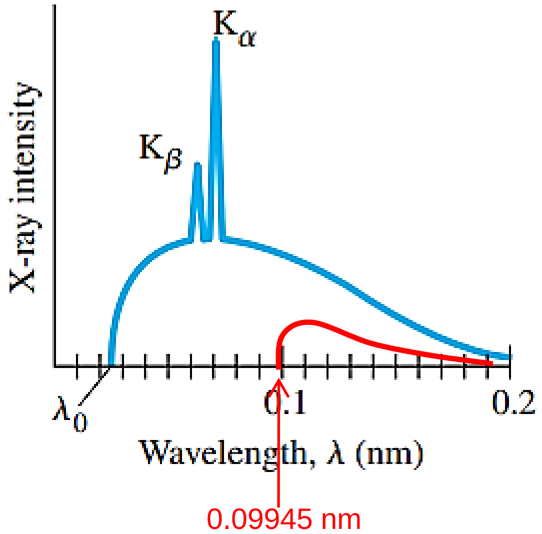


Fig. 6.2

(a)	Explain why there is a minimum wavelength λ_0 for the emitted X-rays.		
	………………………………………………………………………………………………………		
	………………………………………………………………………………………………………	[2]	
	When an **accelerated electron from the cathode loses <u>all</u> of its kinetic energy (KE) in a <u>single</u> head-on collision with the target atom at the anode**,	**1**	
	the **KE lost is converted into an <u>x-ray photon</u> of <u>maximum</u> <u>energy</u>, <u>hence</u> minimum wavelength**.	**1**	

	(b)	Show that λ_0 equals to 0.024 nm.	
			[1]
		From (a), Loss in EPE as electron moves from cathode to anode = Maximum KE gained just before it hits the anode = Maximum energy of photon emitted So, $\boldsymbol{eV_0 = hc/\lambda_0}$ $\Rightarrow \boldsymbol{\lambda_0 = hc/eV_0}$ $\Rightarrow \boldsymbol{\lambda_0 = (6.63 \times 10^{-34})(3.00 \times 10^{8}) / (1.60 \times 10^{-19})(50 \times 10^{3})}$ $\Rightarrow \lambda_0 = 2.48625 \times 10^{-11} = 0.0248625 \times 10^{-9}$ m $\approx$ 0.024 nm	**1**
	(c)	Sketch on Fig. 6.2 a graph to show the intensity variation with wavelength if the accelerating potential difference is reduced to one-quarter of its original value.	[2]
		Graph of **similar shape**, **below** the original graph (intensity lowered at all wavelengths), $\lambda_0 = hc/eV_0$ Since h,c,e are constants, thus **λ_0 is inversely proportional to V_0.** Thus **if V_0 is one-quartered, λ_0 will be increased by 4 times!** **New λ_0 = 4 x 0.0248625 nm = 0.09945 nm ≈ 0.1 nm AND without any characteristic lines.** 	**1** **1**

7 An induced nuclear fission reaction may be represented by the equation

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n$$

The variation with nucleon number A of the binding energy per nucleon B_E is illustrated in Fig. 7.1.

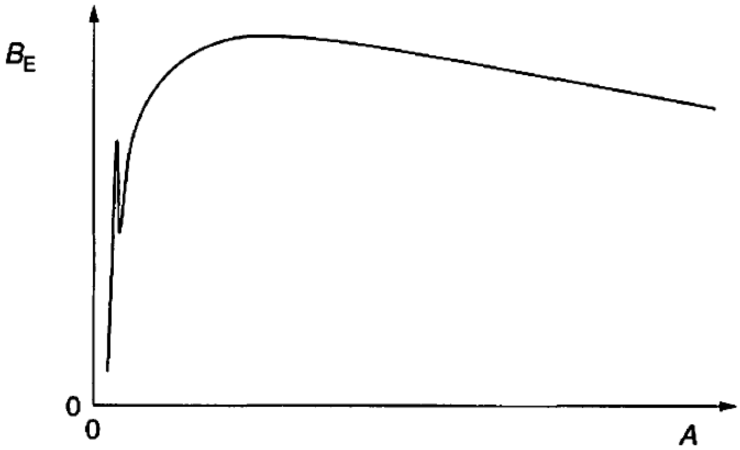


Fig. 7.1

(a) State an approximate value, in MeV, for the maximum binding energy per nucleon.

maximum binding energy per nucleon = …………………… MeV [1]

L1 Maximum binding energy per nucleon = **8.8 MeV (or 9 MeV)** (for Fe-56) **1**

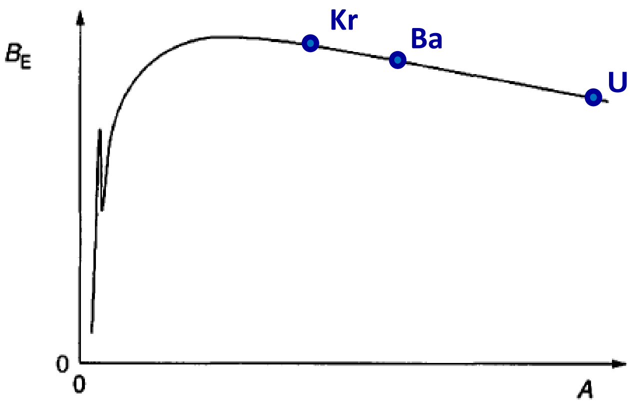
(b) On Fig. 7.1, mark approximate positions for the nuclei of

(i) uranium-235 (label the position U),

(ii) barium-141 (label the position Ba),

(iii) Krypton-92 (label the position Kr). [3]

Solution:



Mark scheme:
1 mark – In the ascending order, Kr, Ba and U **1**
1 mark – All markings on the right-hand side of the peak (A = 56) **1**
1 mark – Relative positions **1**

	(c)	By reference to binding energy per nucleon, explain why energy is released in this fission reaction.	
		…………………………………………………………………………………………………	
		…………………………………………………………………………………………………	
		…………………………………………………………………………………………………	
		…………………………………………………………………………………………………	
		…………………………………………………………………………………………………	
		…………………………………………………………………………………………………	
		…………………………………………………………………………………………………	
		…………………………………………………………………………………………………	[3]
		In the fission reaction, the **product** nuclides (Kr and Ba) have a **greater binding energy per nucleon** than the reactants (U and n, where n has zero binding energy). **Since the total number of nucleons is unchanged in the reaction**, the **total binding energy** of the products is greater than that of the reactants. This means that the **total energy released in the formation of Kr and Ba** is **more than** the **total energy absorbed during the disintegration of U**. Hence there is a *net* release in energy.	**1** **1** **1**

8 Read the passage below and answer the questions that follow.

Torque from a Vehicle Engine

An internal combustion engine used on a vehicle operates over a limited rotational speed which can be controlled by the driver. As the driver increases the depression on the accelerator pedal, the input power to the engine will increase to a maximum when the throttle is fully opened. The power delivered to the wheels of the vehicle will also reach a maximum value.

The output torque of the engine is transmitted to the forward driving force on the vehicle's wheels. The transmission of the output torque of the engine is done through a gearbox which consists of several gear ratios capable of providing the required driving force to suit the different driving speeds and accelerations.

The gear ratio is the ratio of the rotational speed of the vehicle's engine to the rotational speed of the vehicle's wheel. A high gear ratio is required at low vehicle's speeds to provide a higher torque.

A vehicle starts to move off with the highest gear ratio, namely gear 1. As the vehicle's speed increases, the gear ratio changes from gear 1 to gear 4, with gear 4 being the lowest gear ratio. The lowest gear ratio is to provide for the maximum speed achievable. Thus, the forward driving force on the vehicle's wheels will change with the speed of the vehicle for different gears.

As the vehicle moves, it encounters a total resistive force that opposes its motion.

Fig. 8.1 shows how the speed of the vehicle affects the available force F at the wheels for different gears and the total resistive force on a 1200 kg vehicle when the input power to the engine is maintained at the maximum value. The available force is the maximum forward driving force that can be transmitted to the wheels.

To stop the vehicle quickly from a certain speed, the driver steps on the brake pedal to produce a braking force on the wheels, and at the same time, the power of the engine is removed completely. The maximum braking force of the car is 9300 N.

When a vehicle moves up an inclined slope, it encounters a climbing resistance that depends on the gradient of the slope. The gradient of the slope is defined as the ratio of the increase in height to the horizontal distance moved in percentage value.

The chart in Fig. 8.2 shows how the climbing resistance is affected by the gradient of the slope.

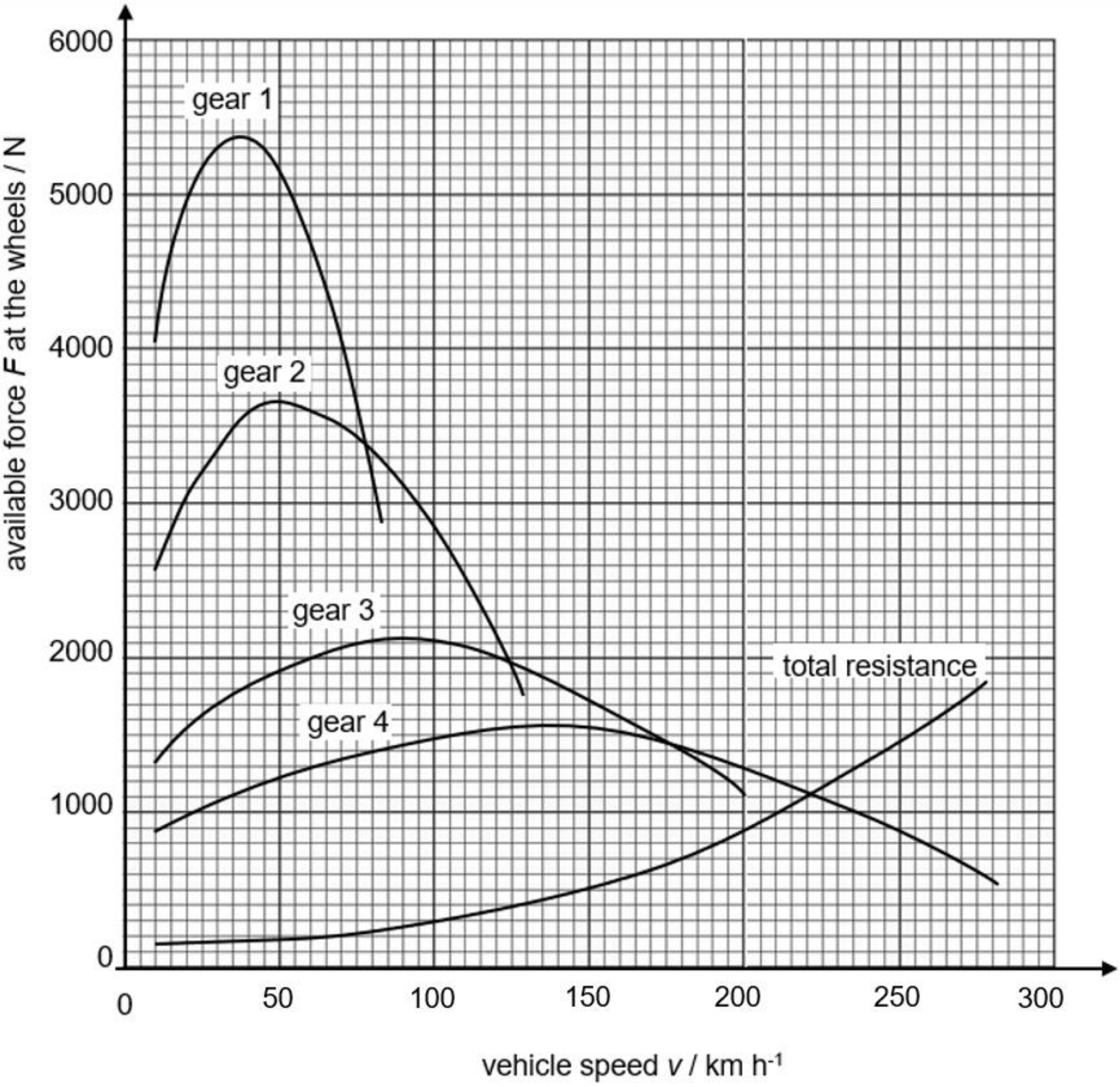

available force F at the wheels / N
6000
5000
4000
3000
2000
1000
0
gear 1
gear 2
gear 3
gear 4
total resistance
0
50
100
150
200
250
300
vehicle speed v / km h-1

Fig. 8.1

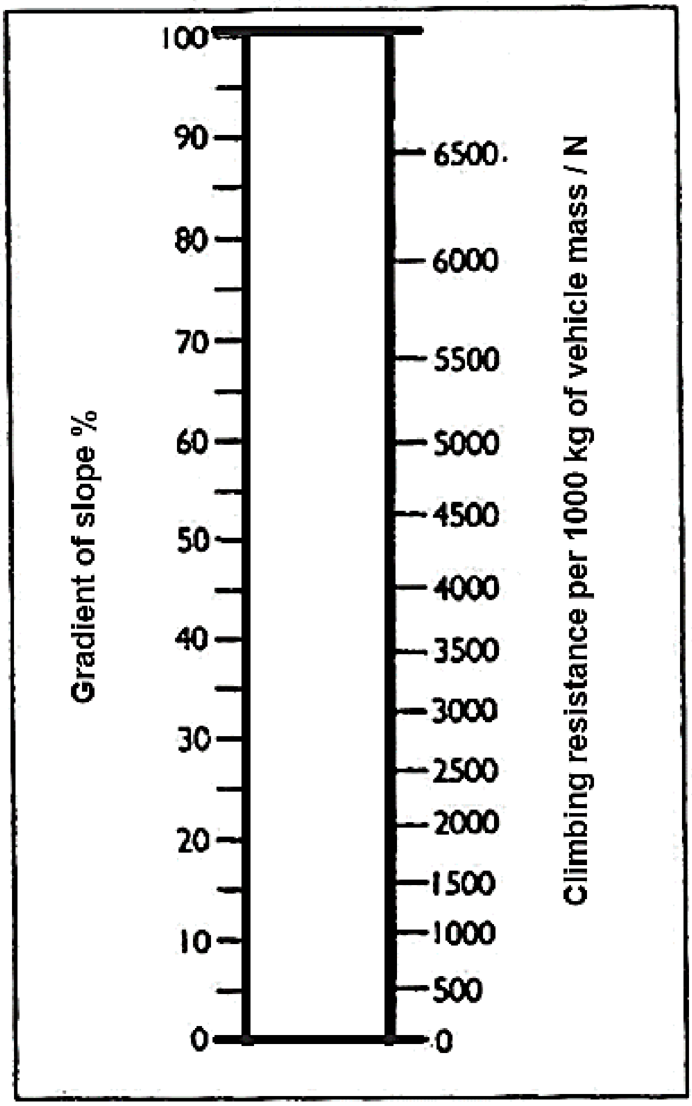


Fig. 8.2

(a)	Explain why gear 1, is used to accelerate the vehicle from rest.		
	………		
	……	[1]	
	At low speed, the driver wishes to **increase speed at the <u>fastest rate</u> (or increase speed in the <u>shortest possible time</u>)** and hence the driving force should be largest and this is possible with gear 1.	**1**	
(b)	Explain what is meant by the term *available force* at the wheels.		
	………		
	……	[1]	
	The **<u>maximum</u>** <u>forward driving force</u> on the wheels when the engine is given the full power.	**1**	

	(c)	The vehicle is travelling at 100 km h^{-1} on a horizontal road and gear 3 is engaged by a driver.		
		(i)	State the available force at the wheels and the resistive force.	
			available force = ……………………………..…….N	
			resistive force =……………………………... N	[2]
			Available driving force = 2100 N Resistive force = 300 N	**1** **1**
		(ii)	Calculate the maximum acceleration.	
			maximum acceleration = ………………………..……..m s^{-2}	[2]
			$F_{net} = ma$ 2100 - 300 = 1200 *a* *a* = 1800 / 1200 = 1.5 m s^{-2}	 **1** **1**
		(iii)	Explain why gear 3 is the optimum gear for maximum power output at a speed of 100 km h^{-1}.	
			…………………………………………………………………………………………………...	
			……………………………………………………………………………………………..	[1]
			At gear 3, the **available force remains relatively constant when speed decreases slightly below 100 km h^{-1}.**	**1**
		(iv)	The driver wishes to overtake another vehicle which is also travelling at 100 km h^{-1}. Explain whether he needs to change gear.	
			…………………………………………………………………………………………………...	
			……………………………………………………………………………………………..	[2]
			Yes. The driver needs to change to gear 2 to get a higher available force. This is because the net forward force will be higher and he can move with a larger acceleration. OR No. At a constant speed of 100 km h^{-1}, he just needs to overcome the resistive force of about 300 N. Thus he does not need a maximum force (available force of 2100 N). He just needs to depress the accelerator more to increase the driving force up to a maximum of 2100 N. *(Award credits based on good application of physics)*	**1** **1** **[1]** **[1]**

	(d)	**(i)**	Starting from the definition of work done, show that the power output of the vehicle is given by the expression power output = driving force x speed	
				[2]
			From definition of work done: *work done by driving force W* = ***average*** *driving force F x displacement s moved* ***in the*** *direction of F* From definition of power: *power output P* *= work done per unit time* *= Fs / t* where *t* is the time taken to do work of *Fs* *= F (s/t)* *= driving force F x speed s/t*	**1** **1**
		(ii)	Explain why for a given power delivered to the engine, the available force at the wheels for gear 3 is smaller than that for gear 2.	
			………………………………………………………………………………………………...	
			………………………………………………………………………………………………...	
			………………………………………………………………………………………………...	
			……………………………………………………………………………………………...	[2]
		The **vehicle speed is larger when gear 3** is used. **Since power output = driving force x speed** **For a given power output, at higher speed, the available (driving) force is smaller.**		**1** **1**
	(e)	State the maximum possible speed of the vehicle.		
		maximum possible speed = ……..……………….... km h^{-1}		[1]
		220 km h^{-1} At this speed, the maximum driving force = total resistance force. So the net force is zero. Above 220 km h^{-1}, the net force is opposing the motion and the vehicle will slow down.		**1**

	(f)	The vehicle is moving up a slope inclined at 20° to the horizontal.		
		(i)	Show that the gradient of the slope, in percentage, is 36%.	
				[1]
			gradient = (increase in height / horizontal distance moved) x 100% = tan θ x 100% = tan 20° x 100% = 36.4% = 36%	1
		(ii)	Use Fig. 8.2 to determine the climbing resistance on the car.	
			climbing resistance = ……………………….N	[2]
			From chart, when gradient of slope is 36%, climbing resistance **per 1000 kg** = 3250 N So **for 1200 kg**, climbing resistance = 1200/1000 x 3250 = 3900 N	1 1
		(iii)	Using the answer to **(f)(ii)** and **Fig. 8.1**, estimate and explain the maximum speed at which the vehicle can move up the slope.	
			………………………………………………………………………………………...	
			………………………………………………………………………………………..	[2]
			To overcome the climbing resistance of 3900 N, the difference between available force and the total resistance must be more than 3900 N. Referring to Fig. 8.1, **gear 1 must be used**. The maximum speed is about **72.5 km h^{-1}**.	1 1
	(g)	The vehicle is travelling up the slope with a speed of 40 km h^{-1}. The driver intends to stop the car by applying the maximum braking force. Estimate the distance moved along the slope before the car stop.		

		distance moved = ……………………………m	[3]
		Let the distance be d and the braking force be B. Total retarding force = B (from text) + climbing resistance + total resistance (from Fig. 8.1) = 9300 + 3900 + 150 = 13350 N Assuming the total resistance is also constant throughout d, then loss in K.E. = work done against the total retarding force $\frac{1}{2}$ (1200) (20 000/3600)^2 = 13350 x d d = 1.39 m	 **1** **1** **1**

-- END OF PAPER 2 --

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