VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2004

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Figures									Letter:
Words									

PHYSICS

Written examination 2

Wednesday 10 November 2004

Reading time: 9.00 am to 9.15 am (15 minutes)
Writing time: 9.15 am to 10.45 am (1 hour 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

Area	*Number of questions*	*Number of questions to be answered*	*Number of marks*
1. Motion	14	14	36
2. Gravity	4	4	14
3. Structures and materials	8	8	24
4. Ideas about light and matter	6	6	16
			Total 90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and an approved graphics calculator (memory cleared) and/or one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied
- Question and answer book of 23 pages, with a detachable data sheet in the centrefold.

Instructions
- Detach the data sheet from the centre of this book during reading time.
- Write your **student number** in the space provided above on this page.
- Answer all questions in the spaces provided.
- **Always** show your working where space is provided because marks may be awarded for this working.
- All written responses must be in English.

Students are NOT permitted to bring mobile phones and/or any other electronic communication devices into the examination room.

AREA 1 – Motion

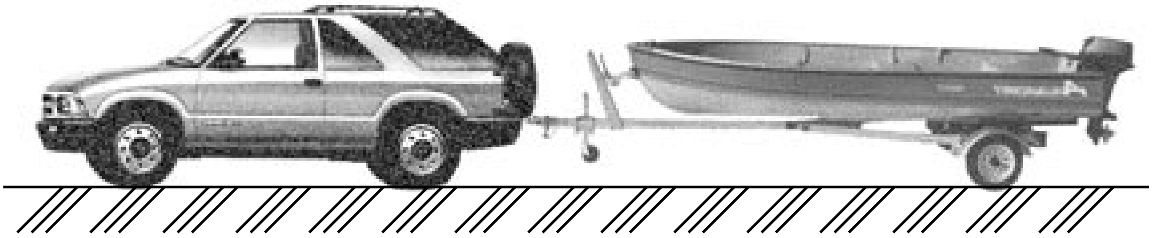

Figure 1

Figure 1 shows a car of mass 1600 kg towing a boat and trailer of mass 1200 kg.

The driver changes the engine power to maintain a constant speed of 72 km h^{-1} on a straight road.
The total retarding force on the car is 1400 N and on the boat and trailer 1200 N.

Question 1
Calculate the driving force exerted by the car at this speed.

N

2 marks

To overtake another car the driver accelerates at a constant rate of 1.20 m s^{-2} from 72 km h^{-1} until reaching 108 km h^{-1}.

Question 2
Calculate the distance covered during this acceleration.

m

3 marks

Question 3

Calculate the tension in the coupling between the car and trailer during the acceleration. (Assume the same retarding forces of 1400 N and 1200 N respectively.)

N

3 marks

A delivery van of mass 1200 kg, travelling south at 20 m s^{-1}, collides head-on with a power pole. The impact crushes the crumple zone of the van by 0.60 m bringing the van to rest against the pole.

Question 4

Calculate the average force that the pole exerts on the van.

N

3 marks

Question 5

Calculate the time for the impact.

s

2 marks

Question 6

Calculate the initial momentum and final momentum of the van and explain how momentum has been conserved in this collision.

3 marks

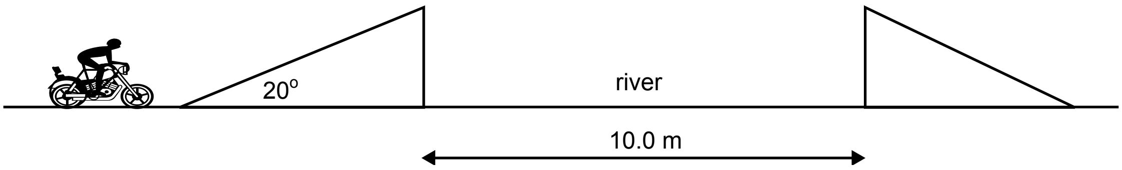

Figure 2

Figure 2 shows a motorcycle rider using a 20° ramp to jump her motorcyle across a river that is 10.0 m wide.

Question 7

Calculate the minimum speed that the motorcycle and rider must leave the top of the first ramp to cross safely to the second ramp that is at the same height. (The motorcycle and rider can be treated as a point-particle.)

($g = 9.8$ m s^{-2})

m s^{-1}

4 marks

Two students are discussing the forces on the tyres of a car. Both agree that there must be a friction force acting on the tyres of a car. The first student claims that the friction force acts to oppose the motion of the car and slow it down, for example, when braking. The second student claims that friction acts in the direction of motion as a driving force to speed the car up when accelerating.

Question 8

On the diagram of the front-wheel drive car in Figure 3 clearly show all the forces acting **on the tyres** of the car **when it is accelerating** forwards in a straight line. Use arrows for the force vectors to show both the **magnitude** and **point of action** of the different forces.

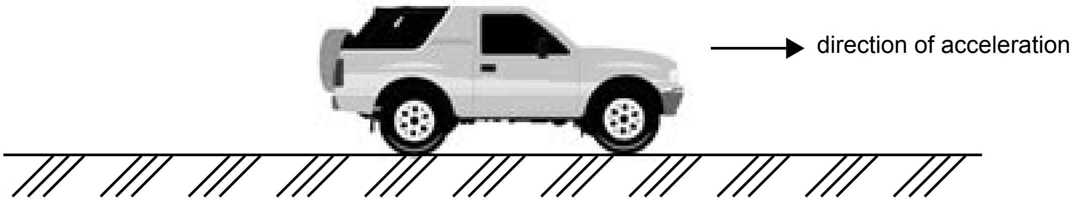

Figure 3

3 marks

Question 9

On the diagram of the same car in Figure 4 clearly show all the forces acting **on the tyres** of the car **when it is braking** in a straight line. Use arrows for the force vectors to show both the **magnitude** and **point of action** of the different forces.

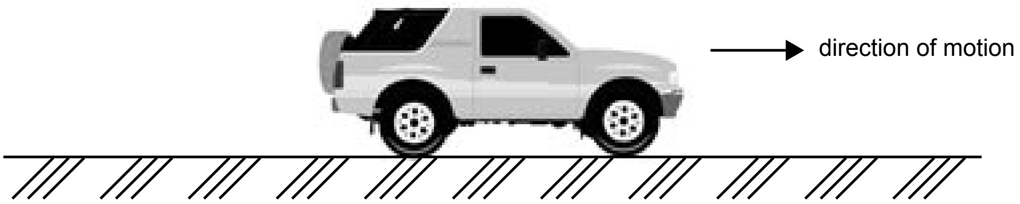

Figure 4

2 marks

The sign below is often seen just before a circular bend in the road as a warning for trucks to slow down.

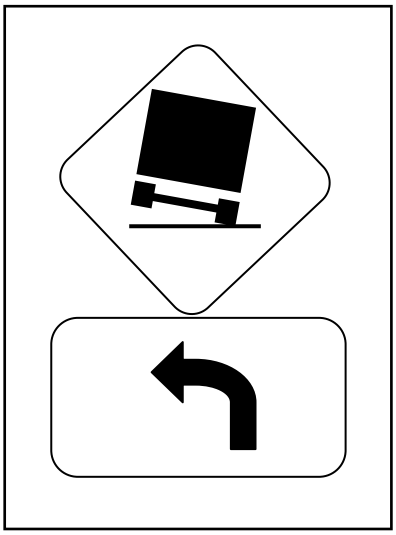

Figure 5

Question 10

The typical recommended speed for traffic on these circular bends is 50 km h^{-1}. Suggest **one** way to make it safer for trucks travelling around the bend at this recommended speed of 50 km h^{-1}. Give a reason for your answer.

2 marks

The following quote was taken from the NASA web site.

To safely reach the surface of Mars, a spacecraft must decelerate from 21 000 km h^{-1} in a matter of minutes and be able to protect its payload as it lands. The Mars Exploration Rovers of 2003 will use a proven airbag system.

Both physics and non-physics students alike would agree that airbags result in a ‘softer collision’.

Question 11

Explain the meaning of the term softer collision in the context of an airbag.

3 marks

Use the following information and Figure 6 to answer Questions 12, 13 and 14.

A car is on top of a hill at X, h metres above the top of a cliff. The top of the cliff is H metres above the water level. The brakes are released and the car begins to roll back down the hill. When the car reaches the cliff at Y it is projected horizontally and travels a horizontal distance, d metres, from the cliff edge. It enters the water at Z.

Take the acceleration due to gravity as g downwards. (For the following questions, ignore air resistance.)

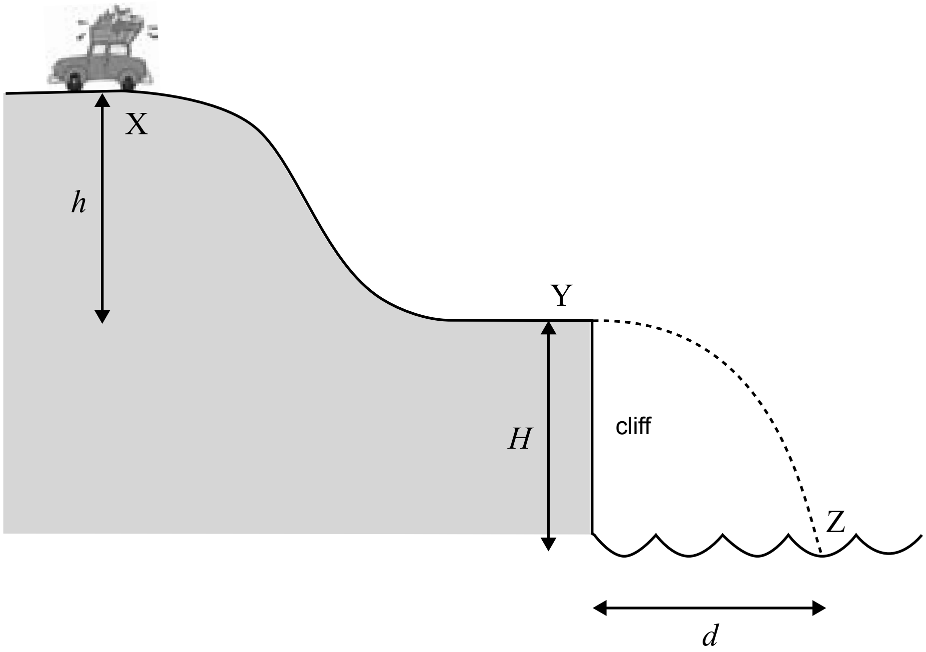

Figure 6

Question 12

Which of the expressions (**A.–D.**) gives the speed of the car at point Y?

A. $\sqrt{2gh}$

B. $\sqrt{2gH}$

C. $\sqrt{2g(h+H)}$

D. $\sqrt{2g(H-h)}$

2 marks

Question 13

Which of the statements (**A.–D.**) for the horizontal component of the velocity of the car at point Z, just before hitting the water, is correct?

A. The horizontal component of the velocity of the car at Z is less than the speed at Y.

B. The horizontal component of the velocity of the car at Z is equal to the speed at Y.

C. The horizontal component of the velocity of the car at Z is greater than the speed at Y.

D. The value of the horizontal component of the velocity at Z depends on the height of the cliff.

2 marks

Question 14

Which of the following expressions (**A.–D.**) is the actual speed of the car just before hitting the water at point Z?

A. $\sqrt{2gh}$

B. $\sqrt{2gH}$

C. $\sqrt{2g(h+H)}$

D. $\sqrt{2g(H-h)}$

2 marks

END OF AREA 1

AREA 2 – Gravity

A spacecraft of mass 400 kg is placed in a circular orbit of period 2.0 hours about Earth.

Question 1

Show that the spacecraft orbits at a height of 1.70×10^6 m above the surface of Earth.

($M_E = 5.98 \times 10^{24}$ kg, $R_E = 6.37 \times 10^6$ m, $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2})

4 marks

Question 2

Calculate the speed of the spacecraft in this orbit of period 2.0 hours.

($M_E = 5.98 \times 10^{24}$ kg, $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2})

m s^{-1}

2 marks

Figure 1 shows the variation of gravitational field with height above Earth's surface.

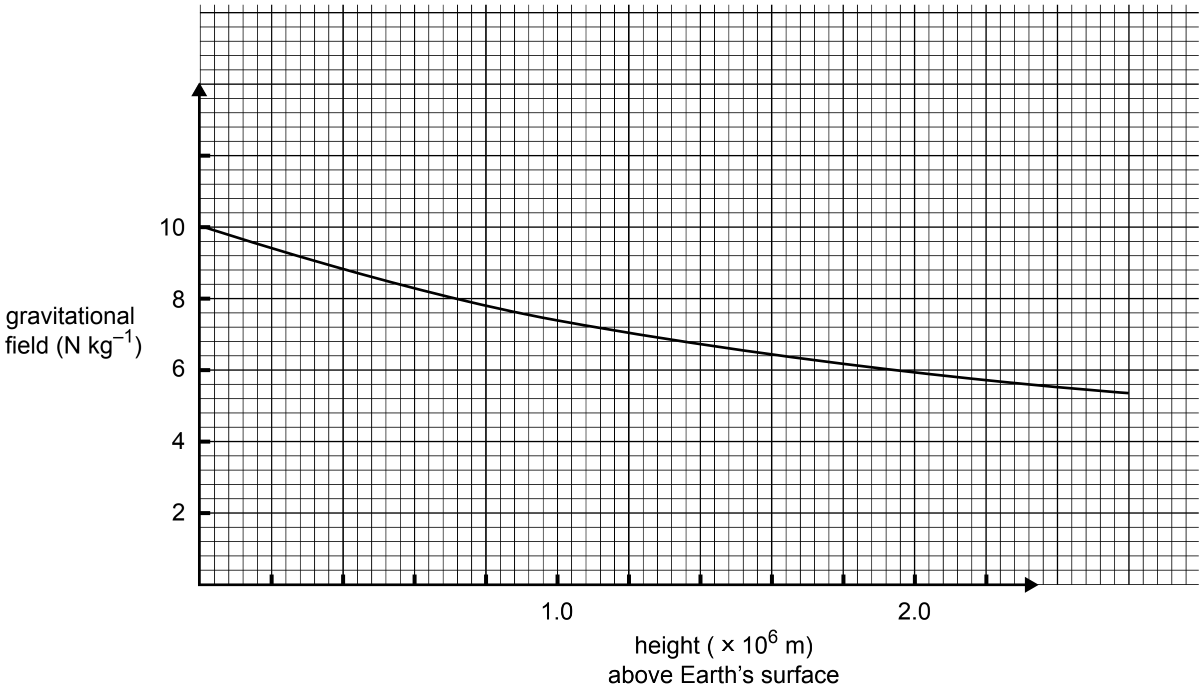

Figure 1

Question 3

Calculate the energy needed to take the 400 kg spacecraft from rest at the surface of Earth and place it in a stable circular orbit of height 1.70×10^6 m. You must show your working.

J

5 marks

Pictures of astronauts in the orbiting spacecraft are ‘beamed’ back to Earth. In these pictures the astronauts appear to be ‘floating’ around inside the spacecraft.

Question 4

Explain why the astronauts appear to be floating around inside the orbiting spacecraft.

3 marks

END OF AREA 2

TURN OVER

AREA 3 – Structures and materials

Figure 1 shows part of a prefabricated bridge structure being lifted into position. The structure is made of concrete and steel. It is held in position at each end by two cranes. The structure has a mass of 300 tonnes. The centre of mass of the bridge structure is 5.0 m from one end and the length of the structure is 25.0 m.

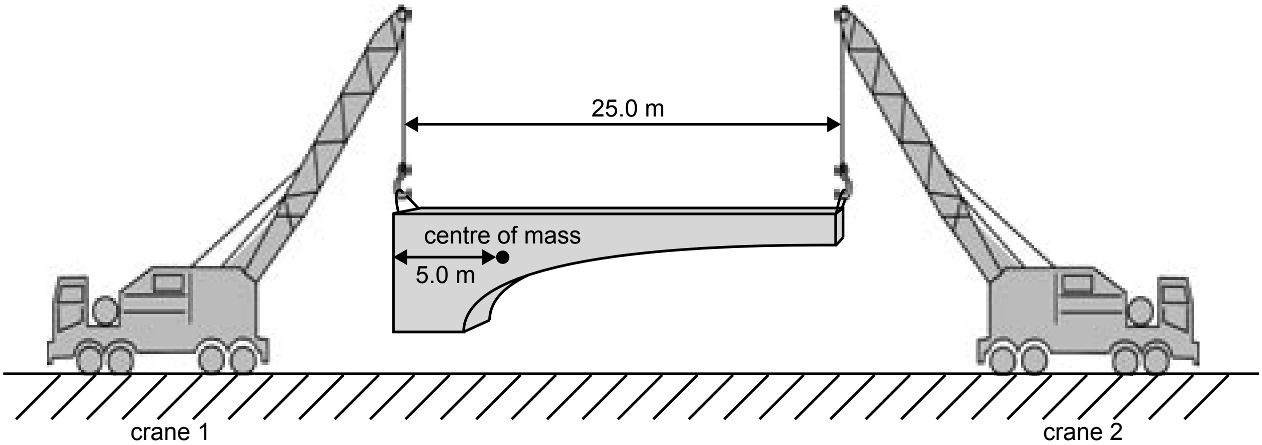

Figure 1

Question 1

Explain the features of this part of the bridge structure that make it strong.

3 marks

Question 2

Calculate the tension in the cable of each crane.

(g = 9.8 N kg^{-1})

crane 1 = N	crane 2 = N

4 marks

Figure 2 shows the stress vs strain graphs of two materials, A and B.

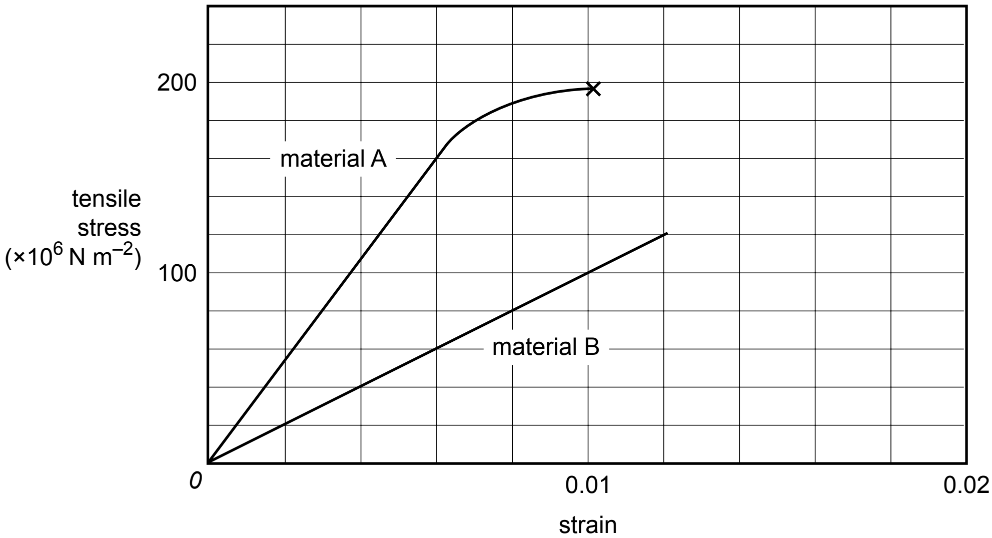

Figure 2

Question 3

Which one of the two materials, A or B, is stronger? Explain your answer using evidence from the graphs.

2 marks

Question 4

Which one of the two materials, A or B, is tougher? Explain your answer using evidence from the graphs.

2 marks

Question 5

Calculate the value of the ratio

$$\frac{\text{Young's modulus of material A}}{\text{Young's modulus of material B}}$$

3 marks

A flat horizontal, uniform stadium roof of mass 50 tonnes is supported at the ends by two 16.0 m steel cables of diameter 4.0 cm making an angle of 60° with the horizontal as shown in Figure 3.

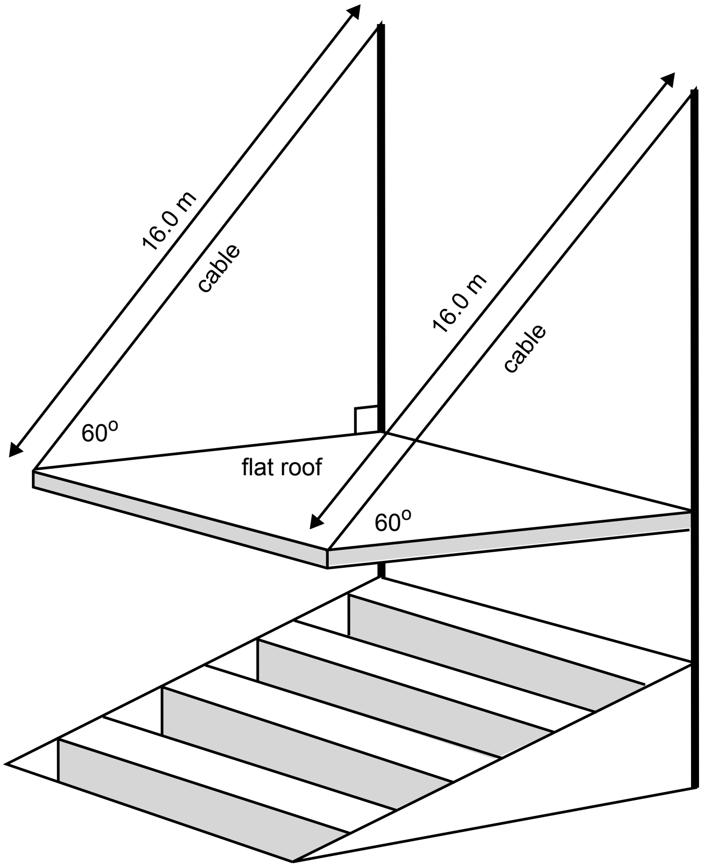

Figure 3

Question 6

Calculate the tension in each cable.

(g = 9.8 N kg^{-1})

N

3 marks

The steel in the cables has a Young's modulus of 2.0×10^{11} Pa and before being used to support the roof the cable is tested at a stress of 2.0×10^{5} N m^{-2}.

Question 7

Calculate the distance that the 16.0 m cable stretches when tested at a stress of 2.0×10^{5} N m^{-2}.

m

3 marks

Question 8

Calculate the energy stored in each 4.0 cm diameter cable supporting the stadium roof when it is tested up to a stress of 2.0×10^{5} N m^{-2}.

J

4 marks

END OF AREA 3
TURN OVER

AREA 4 – Ideas about light and matter

Cesium metal is illuminated by green light with a wavelength of 550 nm.

Question 1

Calculate the energy of a photon of green light.

($h = 4.14 \times 10^{-15}$ eV s, $c = 3.00 \times 10^{8}$ m s^{-1})

eV

2 marks

The work function of cesium is 2.10 eV.

Question 2

Calculate the maximum kinetic energy of the electrons ejected from the metal surface when green light illuminates cesium metal.

eV

2 marks

AREA 4 – continued

Violet light now illuminates the cesium metal and the maximum kinetic energy of the photoelectrons is 2.80 eV.

Question 3

Show that the maximum speed of the electrons ejected from the metal surface is 9.9×10^5 m s^{-1}.

($e = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$ kg)

3 marks

An electron is accelerated from rest between two parallel charged plates in a vacuum with a potential difference of 100 V as shown in Figure 1 below. The plates are separated by a distance of 0.02 m.

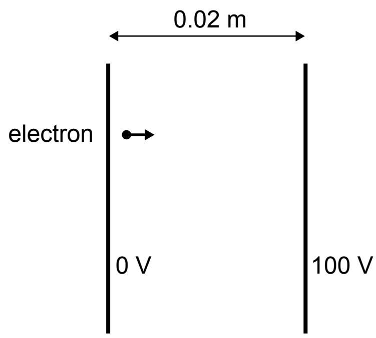

Figure 1

Question 4

Calculate the electric field strength between the parallel plates.

V m^{-1}

2 marks

Question 5

Calculate the de Broglie wavelength of the electron just before it hits the positive plate.

($e = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$ kg, $h = 6.63 \times 10^{-34}$ J s)

m

4 marks

Figure 2 shows the energy levels of an atom.

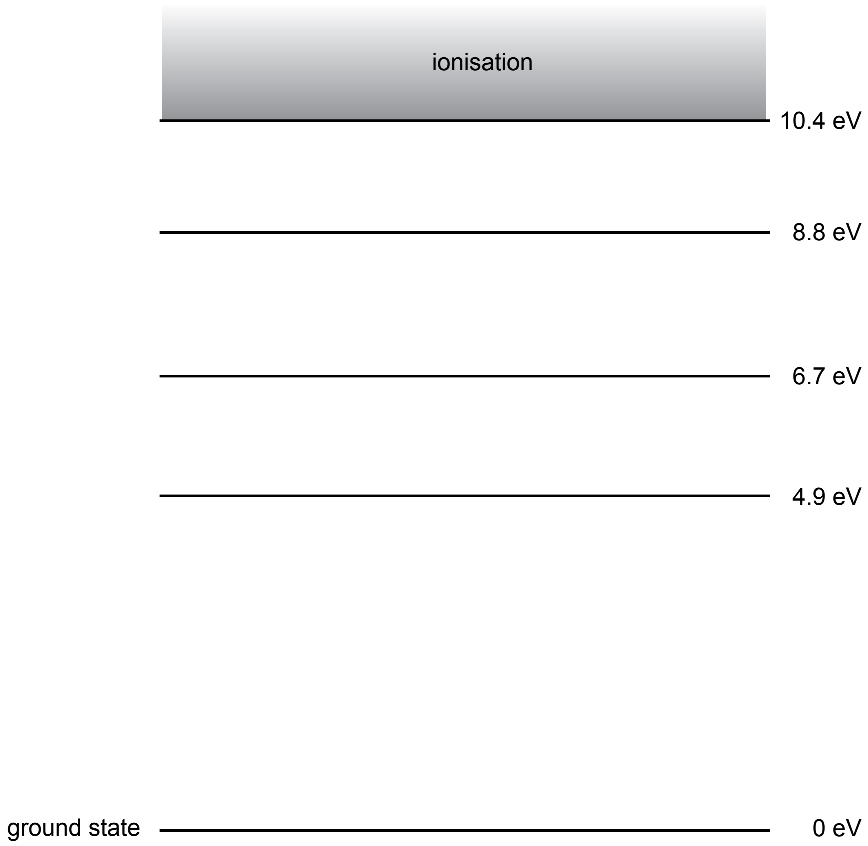

Figure 2

Question 6

For atoms in the 2nd excited state (6.7 eV), calculate **all** the possible energies of the photons emitted from transitions back to the ground state.

eV

3 marks

END OF QUESTION AND ANSWER BOOK

PHYSICS

Written examination 2

DATA SHEET

Directions to students

Detach this data sheet before commencing the examination. This data sheet is provided for your reference.

1	velocity; acceleration	$v = \frac{\Delta x}{\Delta t}; \quad a = \frac{\Delta v}{\Delta t}$
2	equations for constant acceleration	$v = u + at$ $x = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2ax$ $x = \frac{1}{2}(v + u)t$
3	Newton's second law	$F = ma$
4	circular motion	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
5	Hooke's law	$F = -kx$
6	elastic potential energy	$\frac{1}{2}kx^2$
7	gravitational potential energy near the surface of the Earth	mgh
8	kinetic energy	$\frac{1}{2}mv^2$
9	torque	$\tau = Fr$
10	Newton's law of universal gravitation	$F = G\frac{M_1 M_2}{r^2}$
11	gravitational field	$g = G\frac{M}{r^2}$
12	stress	$\sigma = \frac{F}{A}$
13	strain	$\varepsilon = \frac{\Delta L}{L}$
14	Young's modulus	$E = \frac{\text{stress}}{\text{strain}}$
15	electric force on charged particle in an electric field	$F = qE$
16	electric field between charged plates	$E = \frac{V}{d}$
17	energy change of charged particle moving between charged plates	$\Delta E_k = qV$
18	photoelectric effect	$E_{k\,\max} = hf - W$
19	photon energy	hf
20	photon momentum	$p = \frac{h}{\lambda}$
21	de Broglie wavelength	$\lambda = \frac{h}{p}$

Gravitational field strength at the surface of Earth	g	=	$9.8\ \text{N kg}^{-1}$
Universal gravitational constant	G	=	$6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
Mass of Earth	M_E	=	$5.98 \times 10^{24}\ \text{kg}$
Radius of Earth	R_E	=	$6.37 \times 10^{6}\ \text{m}$
Mass of the Sun	M_{SUN}	=	$2.0 \times 10^{30}\ \text{kg}$

Mass of the electron	m_e	=	$9.1 \times 10^{-31}\ \text{kg}$
Charge on the electron	e	=	$1.6 \times 10^{-19}\ \text{C}$
Planck's constant	h	=	$6.63 \times 10^{-34}\ \text{J s}$
	h	=	$4.14 \times 10^{-15}\ \text{eV s}$
Speed of light	c	=	$3.0 \times 10^{8}\ \text{m s}^{-1}$

Prefixes/Units

m = milli = 10^{-3}

μ = micro = 10^{-6}

n = nano = 10^{-9}

k = kilo = 10^{3}

M = mega = 10^{6}

G = giga = 10^{9}

tonne = 10^{3} kg

END OF DATA SHEET