Year 13

Student Pack

Subject:	Physics

Section	Contents
1	- Online resources
2	- Revision tasks
3	- Additional work and learning resources

Online Science resources

- Kerboodle – www.kerboodle.com Online access to textbooks and other resources
- Seneca – www.senecalearning.com Revision activities
- Memrise – www.memrise.com Keyword revision
- OCR – www.ocr.org.uk Exam board specific resources
- Revision science – www.revisionscience.com Online revision resources

Please use the resources above, your notes and your textbooks to work through the following exam style questions.

These are based on topics previously covered in Year 12.

Mark schemes will be emailed to you to allow you to self-assess your work.

Refer to the Physics A datasheet for data, formulae and relationships information.

1 The CD in a computer drive is rotated at constant angular velocity so that it completes 4000 revolutions in a minute.

Calculate:

a the angular velocity of the CD in rad s^{-1}

....

.... (*2 marks*)

b the linear speed of a point 5.0 cm from the centre of the CD

.... (*1 mark*)

c the time, in seconds, taken for the CD to complete one revolution.

.... (*1 mark*)

2 The Moon orbits the Earth in a circle of radius 3.84×10^5 km. It takes 27.3 days to complete one orbit.

Calculate:

a the angular velocity of the Moon in rad s^{-1}

....

.... (*2 marks*)

b the linear speed of the Moon

.... (*1 mark*)

c the magnitude and direction of the Moon's acceleration in its orbit.

....

.... (*2 marks*)

3 **a** Explain why a body moving at constant speed in a circular path needs to have a resultant force acting upon it.

....

.... (*2 marks*)

b **i** A man standing at a point on the equator is really in circular motion about the centre of the Earth.

Calculate the angular speed of the man.

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.... (*2 marks*)

ii The radius of the Earth is 6400 km. The man has a mass of 89 kg. Calculate the resultant force which must act on the man in order for this circular motion to take place.

....

.... (*2 marks*)

iii If the man were to stand on a set of weighing scales calibrated in newtons, what reading would he observe on the scales?

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.... (*3 marks*)

4 A ball attached to the end of a long light string is made to rotate in a horizontal circular path at a constant speed. The forces acting on the ball are its weight, W, and the tension, T, in the string.

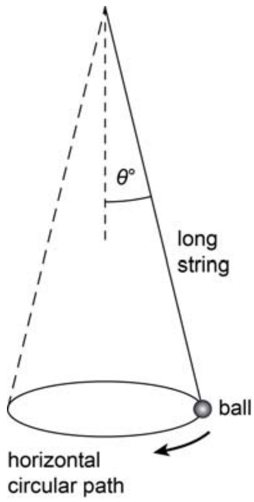

Figure 1

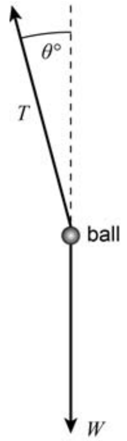

Figure 2

a With reference to the free-body force diagram in Figure 2, explain how it is possible for the ball to move with constant speed and yet still be accelerating.

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.... (*4 marks*)

b The ball has a mass of 0.020 kg and moves in a circle of radius 5.0 cm. It completes 72 revolutions per minute.

Calculate:

i the speed of the ball

....

.... (*2 marks*)

ii the magnitude and direction of the force which keeps the ball moving in a circular path.

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.... (*2 marks*)

c Describe and explain how you would expect the path of the ball to change when it is rotated at a higher speed.

....

....

.... (*3 marks*)

5 a A car travels at a constant speed, v, on a circular road of radius, r. The road is banked at an angle, θ, as shown in Figure 3. The car's speed is such that there is no sideways frictional force acting between the tyres and the road surface.

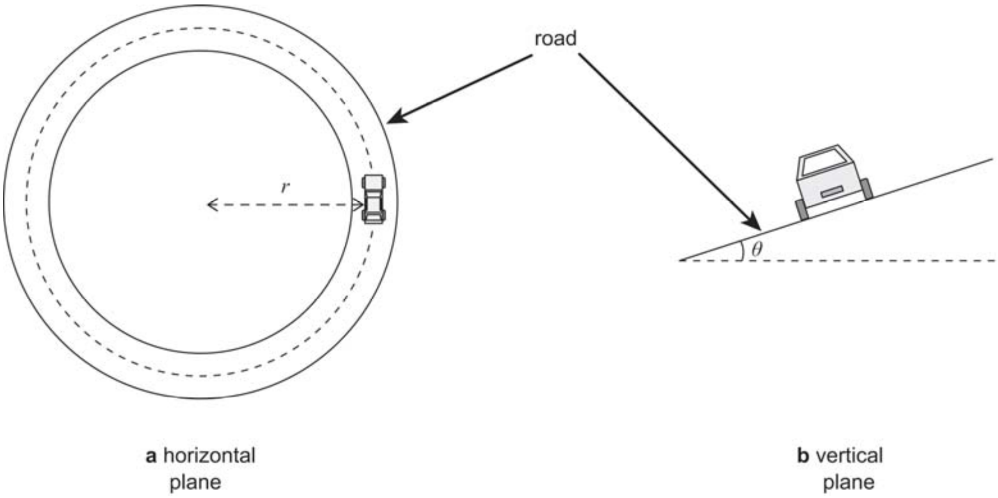

Figure 3

i Mark on Figure **3 b** the forces acting on the car in the vertical plane. Give each of your forces a suitable label.

(*2 marks*)

ii The track is banked at an angle of 18º and the circular path of the road has a radius of 36 m. Calculate the speed which the car must travel so that there is no sideways frictional force between the tyres and the road surface.

....

....

....

.... (*4 marks*)

b The same car later travels on a straight road at a speed of 60 km h^{-1}.It passes over a hump-backed bridge. The top of the bridge may be considered to be the arc of a circle in the vertical plane, as shown in Figure 4.The car passes over the bridge without losing contact with the road surface.

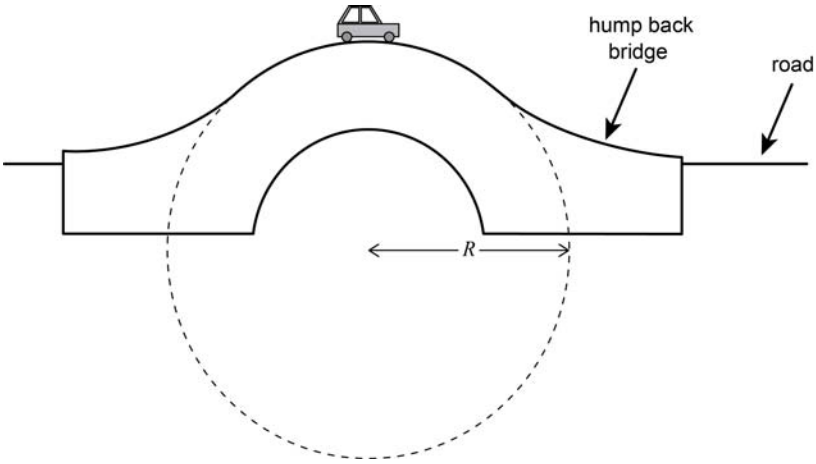

Figure 4

Calculate the radius of curvature of the bridge.

(*3 marks*)

6 Figure 5 shows an aircraft flying with its wings at an angle of 35° to the horizontal in order to fly in a horizontal circle of radius, R. There are two forces acting on the aircraft in the vertical plane: the weight, W, and the lift force, L, generated by the airflow over the wings. The lift force, L, acts at right angles to the surface of the wings at all times.

The aircraft has a mass of 4.0×10^4 kg and flies at a constant speed of $250\ \mathrm{m\,s^{-1}}$.

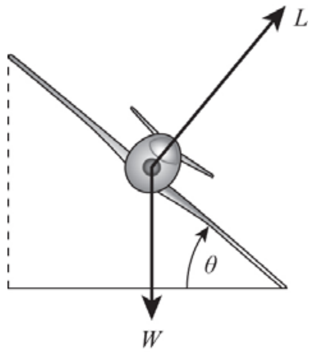

Figure 5

a Calculate the vertical component of L required for horizontal flight.

(*1 mark*)

b Calculate the horizontal component of L.

(*3 marks*)

c Calculate the centripetal acceleration of the aircraft.

(*2 marks*)

d Determine the radius of the circular path flown by the aircraft.

(*2 marks*)

20 Cosmology (The Big Bang)
Exam-style questions

Refer to the Physics A datasheet for data, formulae and relationships information.

1 a Define:

i a *light year*

.... (*1 mark*)

ii *a parsec*.

....

.... (*1 mark*)

b Acrux is the brightest star in the Southern Cross. When viewed through a telescope it is seen to consist of two component stars with a separation of 4.0 arcseconds. Given that Acrux is 320 ly from Earth, determine the distance between the two component stars. Give your answer in metres.

....

....

.... (*3 marks*)

c The Whirlpool galaxy is 23 million light years from the Earth. Calculate the distance to this galaxy in parsecs.

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.... (*2 marks*)

2 The red shift of a galaxy's spectrum can be used to determine the velocity of the galaxy relative to Earth.

a The wavelength of the hydrogen alpha line in the spectrum of a galaxy is measured to be 660.92 nm. The wavelength of the same line measured in the laboratory is 656.28 nm. Calculate the velocity of the galaxy.

....

.... (*2 marks*)

b The table below gives the velocity and distance of five galaxies observed in different constellations.

Galaxy in constellation of	Velocity/km s^{-1}	Distance/Mpc
Virgo	1 200	15
Ursa Major	15 400	190
Corona Borealis	22 000	280
Bootes	39 400	490
Hydra	60 600	760

Plot a graph of the data in the table and use it to determine a value for the Hubble constant.

(*4 marks*)

3 **a** Observations on a binary star system show that each of the stars are rotating about their common centre of mass with an orbital speed of 390 km s^{-1}.

A prominent absorption line due to hydrogen is observed in the spectrum from the binary system. The wavelength of this line measured from a laboratory source is 656.28 nm.

Calculate the maximum and minimum values for the wavelength of this line due to the stars' orbital motion.

....

....

.... (*3 marks*)

b The Andromeda galaxy is currently located at a distance of 725 kpc. It is known to be approaching the Milky Way at a speed of 105 km s^{-1}.

i Atomic hydrogen emits a strong radio signal at a wavelength of 0.211207 m, as measured in the laboratory. The same radio signal is detected in emissions from the Andromeda galaxy. Explain why the wavelength of this signal is different from the value observed in the laboratory.

Calculate the wavelength of the signal in Andromeda's spectrum. You should work to 6 d.p. in this calculation.

....

....

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.... (*4 marks*)

ii It is thought that the Andromeda galaxy may eventually collide with the Milky Way. Estimate the time, in s, which will elapse before a possible impact with the Milky Way.

....

.... (*2 marks*)

iii State one assumption you have made in determining your answer to **ii**.

.... (*1 mark*)

4 a Explain how astronomers are able to deduce that most galaxies are moving away from Earth.

....

....

.... (*3 marks*)

b Figure 1 shows a graph of recessional speed of some galaxies plotted against their distance from Earth.

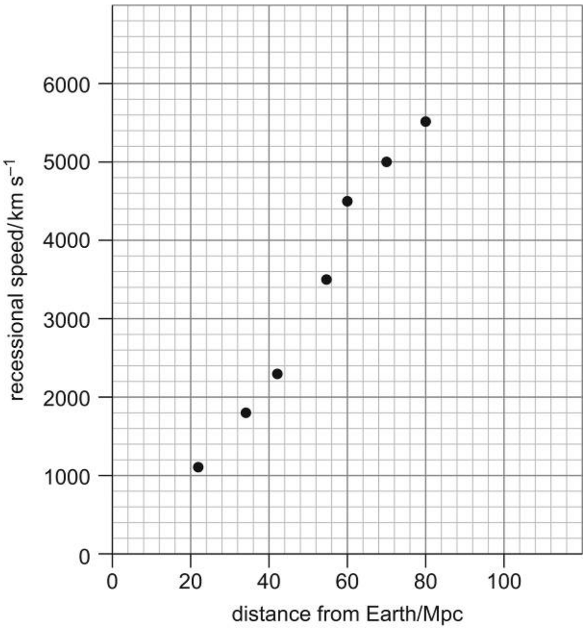

Figure 1

Sketch a best-fit straight line on Figure 1 and hence determine a value for the Hubble constant.

....

.... (*2 marks*)

c The presence of calcium in a galaxy is indicated by a strong absorption line in the spectrum. In the laboratory, this line occurs at 390.0 nm. The same line is observed to occur at 395.7 nm in the spectrum from a particular galaxy.

i Calculate the recessional speed of the galaxy.

....

....

.... (*3 marks*)

ii Use Figure 1 to estimate the distance of the galaxy from Earth. ....

(*1 mark*)

5 The graph shows the spectrum of the cosmic microwave background radiation.

The shape of the graph is consistent with a black-body spectrum to which the Wien displacement law may be applied.

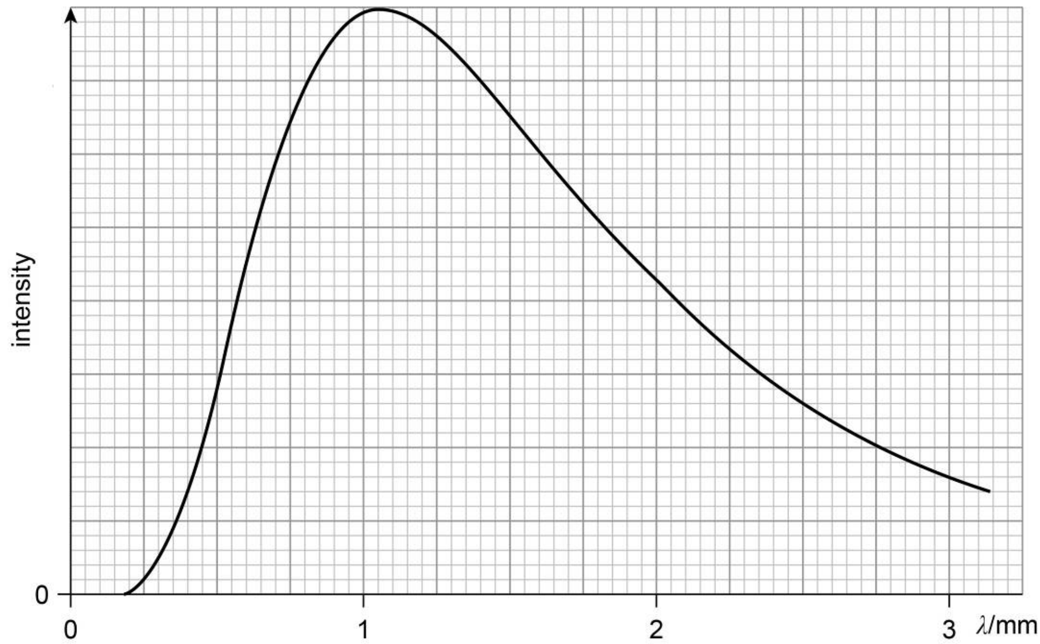

Figure 2

a Use the graph to estimate the black-body temperature.

Wien constant = 2.9×10^{-3} m K

(*2 marks*)

b Explain how your answer to **a** provides evidence in support of the Big Bang theory for the origin of the Universe.

(*2 marks*)

c State and explain another piece of experimental evidence in support of the Big Bang theory.

(*2 marks*)

6 A binary star system consists of two stars, **A** and **B**, rotating about their common centre of mass. Figure 3 shows three absorption lines in the spectra from the binary system measured over a period of time. The diagram is not drawn to scale.

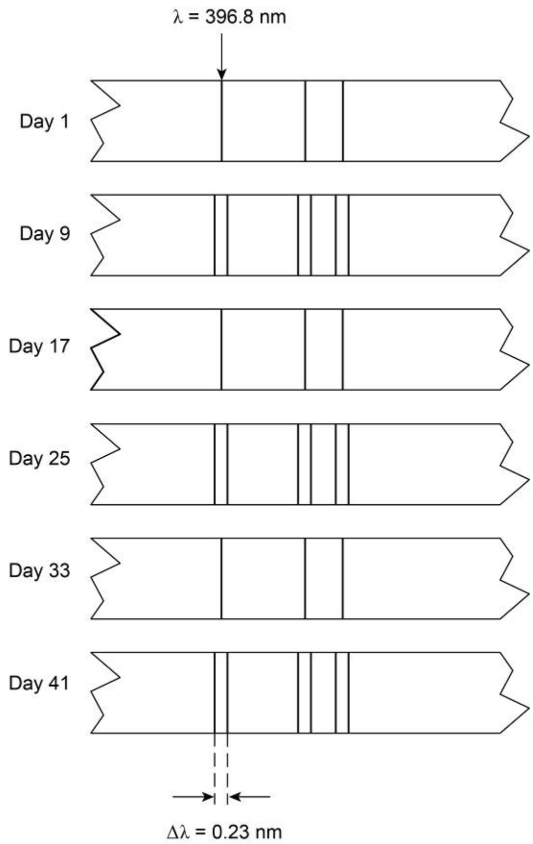

Figure 3

a Use Figure 4 to describe the motion of the system and explain why the observed absorption lines change with time in the way illustrated in Figure 3.

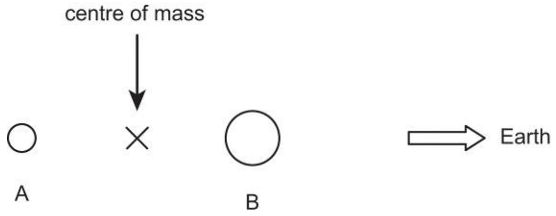

Figure 4

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(*5 marks*)

b What is the period of this binary system? ....

(*1 mark*)

c Using the wavelength values given in Figure 3, calculate the observed speed of star **A** relative to star **B**.

....

....

(*2 marks*)

18 Gravitational fields
Exam-style questions

Refer to the Physics A datasheet for data, formulae and relationships information.

1 **a** Write a word equation stating Newton's law of gravitation.

....

....

.... (*2 marks*)

b Venus may be assumed to be a spherical planet with the following properties:

mass of Venus = 4.87×10^{24} kg

radius of Venus = 6.05×10^{6} m

Calculate the force exerted on a body of mass 2.00 kg on the surface of Venus.

....

.... (*2 marks*)

c The mass of the Earth is 6.0×10^{24} kg and that of the Moon is 7.4×10^{22} kg. If the distance between their centres is 3.8×10^{8} m, calculate at what point on the line joining their centres there is no net gravitational force. You may neglect the effect of the Sun and other planets.

....

....

....

.... (*4 marks*)

2 **a** Write a word equation that defines the gravitational potential at a point in the Earth's gravitational field.

....

....

.... (*2 marks*)

b Explain what is meant by the velocity of escape from a planet.

....

.... (*2 marks*)

c A neutron star has a radius of 11 km and a mass of 2.2×10^{29} kg. A meteorite enters the gravitation field of the neutron star with a negligible kinetic energy. Calculate the speed with which it will strike the surface of the star.

....

....

.... (*3 marks*)

3 a Show that the speed, v, of a particle in a circular orbit of radius, r, around a planet of mass, M, is given by the formula

$$v = \sqrt{\frac{GM}{r}}$$

....

.... (*2 marks*)

b Figure 1 shows two of the moons of Jupiter, Io and Callisto. The moons move in circular orbits around Jupiter. Io is 4.2×10^{8} m from the centre of Jupiter and Callisto is 1.9×10^{9} m from the centre. Callisto has an orbital speed of 8.2 km s^{-1}.

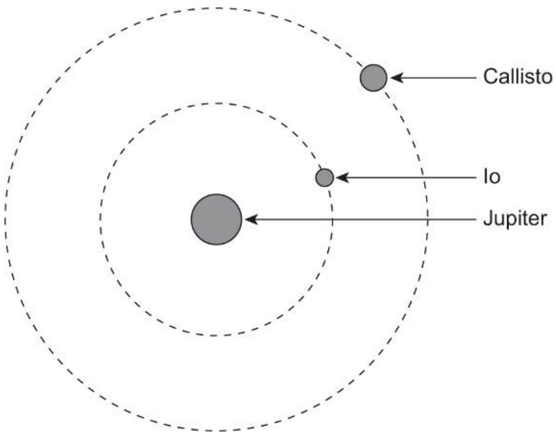

Figure 1

i Determine the mass of Jupiter.

....

.... (*2 marks*)

ii Calculate the orbital speed of Io.

....

.... (*2 marks*)

iii Calculate the value of the ratio

$$\frac{\text{gravitational field strength of Jupiter at Io}}{\text{gravitational field strength of Jupiter at Callisto}}$$

....

.... (*2 marks*)

4 A space station is in a stable circular orbit at a distance of 2.2×10^7 m from the Earth's centre. The radius of the orbit of geostationary satellites is 4.2×10^7 m.

a Use the above data and Kepler's third law to show that the orbital period of the space station is approximately nine hours.

....

....

....

.... (*3 marks*)

b Use your value, or nine hours, for the period of the space station to estimate the magnitude of the Earth's gravitational field strength at the orbit of the space station.

....

....

.... (*3 marks*)

c In its stable orbit, the space station is subject to a gravitational force. State and explain whether work is done by this force.

....

.... (*2 marks*)

d Newton stated in his third law that forces should exist in pairs. State the point of application and the direction of action of the force that forms a pair with the force mentioned in **c**.

....

.... (*2 marks*)

5 **a** **i** State the name given to satellites that orbit the Earth with a period of exactly one day above the equator.

....

.... (*1 mark*)

ii State one other feature of these orbits.

....

.... (*1 mark*)

iii For customers who subscribe to a satellite TV service this type of satellite has a major beneficial effect on their installation requirements. Describe this benefit.

....

.... (*1 mark*)

b Show that the radius of the orbit of a satellite with an orbital period of one day is about 4×10^7 m.

Mass of the Earth is 6.0×10^{24} kg

....

....

.... (*3 marks*)

c **i** State Kepler's third law.

....

(*1 mark*)

ii The Moon orbits the Earth with a period of 27.3 days. Use the information given in **b** to calculate the following ratio:

$$\frac{\text{distance of the Moon from the Earth's centre}}{\text{distance of the satellite from the Earth's centre}}$$

....

.... (*2 marks*)

OCR Physics A, January 2012

6

a State Kepler's first and second laws of planetary motion.

(*3 marks*)

b A low earth orbit (LEO) satellite is one which has a relatively small orbital radius.

Table 1 shows the period, T, and average orbital radius, r, for some LEO satellites.

$T/10^3$ s	$r/10^6$ m	$T^2/10^7$ s^2	$r^3/10^{20}$ m^3
6.3	7.4	4.0	4.05
6.7	7.7	4.5	4.57
7.0	7.9	4.9	4.93
7.2	8.1	5.2	
7.6	8.4	5.9	

Table 1

i Complete the final column of Table 1 by calculating r^3.

(*1 mark*)

ii Plot a graph of T^2 against r^3 on the axes of Figure 2.
Sketch the best fitting straight line through the points.

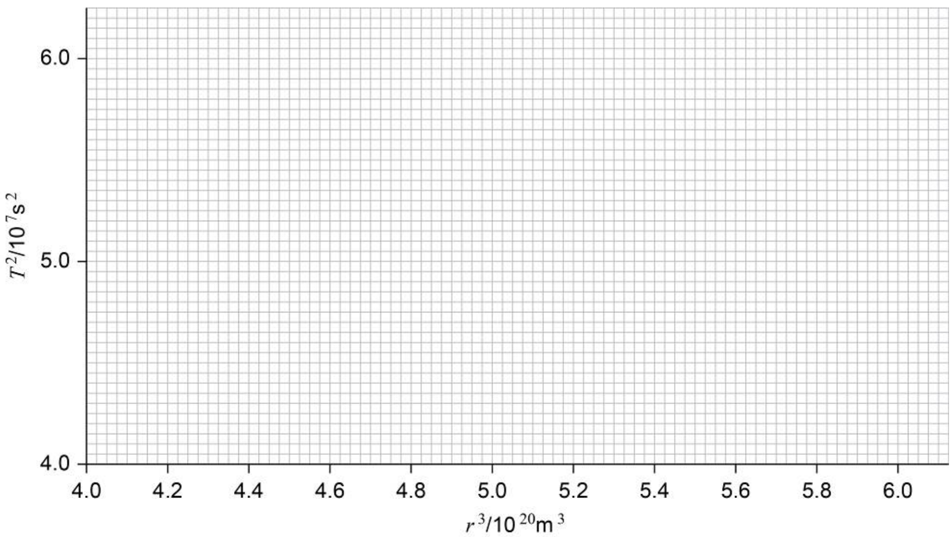

Figure 2

(*2 marks*)

iii Use your graph to calculate a value for the mass of the Earth, showing all your working.

....

.... (*2 marks*)

OCR Physics A, June 2009 (amended)

15 Ideal gases
Exam-style questions

Refer to the Physics A data sheet for data, formulae and relationships information.

1 **a** In an experiment with helium gas at constant volume, the pressure exerted by the gas is measured at 10 ºC intervals from 0 ºC to 100 ºC. Describe how you would use this data to determine a Celsius value for absolute zero.

....

....

.... (*3 marks*)

b A cylinder of volume 5.5×10^{-3} m^3 contains nitrogen at a temperature of 18 ºC and a pressure of 3.0 MNm^{-2}.

Calculate the volume the nitrogen would occupy at a temperature of 0 ºC and a pressure of 1.0×10^5 Nm^{-2}.

....

.... (*2 marks*)

2 **a** The equation relating the pressure, p, and the volume, V, of an ideal gas is

$$pV = nRT$$

Identify the terms n, R, and T.

....

....

.... (*3 marks*)

b A bottle of volume 1.2×10^{-4} m^3 contains air. A vacuum pump reduces the pressure of the air in the bottle to 180 Pa at a temperature of 20 ºC.

Molar mass of air = 0.029 kg mol^{-1}

Calculate:

i the number of air molecules remaining in the bottle

....

.... (*2 marks*)

ii the density of the air remaining in the bottle after evacuation.

....

.... (*2 marks*)

3 a State **two** quantities that increase when the temperature of a given mass of gas is increased while the volume occupied by the gas remains constant.

....

.... (*2 marks*)

b A car tyre when inflated has a volume of $1.4 \times 10^{-2}\,\mathrm{m^3}$. The pressure of the air is measured at a temperature of 17 ºC and recorded as 210 kPa.

The molar mass of air is $0.029\,\mathrm{kg\,mol^{-1}}$.

i Calculate the amount of air, in moles, in the tyre.

....

....

.... (*2 marks*)

ii When the car is driven, the temperature of the tyre increases to 35 ºC.

Assuming that the volume of the tyre is unchanged, calculate the pressure in the tyre at its operating temperature.

....

....

.... (*2 marks*)

4 a A small dust particle in the upper atmosphere is struck by five molecules in succession. The speeds of the molecules are $300\,\mathrm{ms^{-1}}$, $500\,\mathrm{ms^{-1}}$, $700\,\mathrm{ms^{-1}}$, $400\,\mathrm{ms^{-1}}$ and $600\,\mathrm{ms^{-1}}$.

Calculate:

i the mean speed of the molecules, $\bar{c}$

.... (*1 mark*)

ii the root mean square (r.m.s.) speed of the molecules, $\sqrt{\overline{c^2}}$.

....

....

.... (*2 marks*)

b Show that, for an ideal gas, the r.m.s. speed of its molecules is given by the formula

$$\sqrt{\overline{c^2}} = \sqrt{\frac{3RT}{M}}$$

where M is the mass of one mole of the gas in kilograms.

(*3 marks*)

c Calculate, for an ideal gas, the ratio

$$\frac{\text{r.m.s. speed of its molecules at 250 °C}}{\text{r.m.s. speed of its molecules at 25 °C}}$$

(*2 marks*)

d The velocity required for molecules to escape from the Earth's atmosphere is about 11 km s^{-1}. Estimate the temperature to which hydrogen must be heated in order for the r.m.s. speed of its molecules to be equal to this escape velocity.

Molar mass of hydrogen = 2.0×10^{-3} kg mol^{-1}

(*2 marks*)

5 **a** Gas molecules are said to make perfectly elastic collisions with one another.

i State what is meant by a *perfectly elastic collision*.

(*1 mark*)

ii Explain, in terms of the behaviour of its molecules, how a gas exerts a pressure on the walls of its container.

(*4 marks*)

iii Explain, in terms of the behaviour of molecules, why the pressure of a gas in a container of constant volume increases when the temperature of the gas is increased.

....

....

.... (*2 marks*)

b A weather balloon is filled with helium gas. Just before take-off, the pressure inside the balloon is 105 kPa and its internal volume is $5.0 \times 10^3\,\text{m}^3$. The temperature inside the balloon is 20 °C.

The pressure, volume and temperature of the helium gas change as the balloon rises into the upper atmosphere.

i The balloon expands to a volume of $1.2 \times 10^4\,\text{m}^3$ in the upper atmosphere, where the temperature inside the balloon is –30 °C. Calculate the pressure inside the balloon.

....

....

.... (*3 marks*)

ii Suggest why it is necessary to release helium from the balloon as it continues to rise.

....

(*1 mark*)

OCR Physics A, January 2012

6 An ideal gas is trapped in an insulated cylinder by a piston that is free to move. The gas is at atmospheric pressure, p_1.

a The gas is heated from 27 °C to 327 °C. During the heating process the piston is held at its original position.

Show that the pressure immediately after heating is $2p_1$.

....

.... (*2 marks*)

b The piston is now released. The gas pushes the piston out until the pressure of the gas returns to atmospheric pressure, p_1. The volume of the gas increases from its original value V_1 to $1.5V_1$.

Calculate the final temperature of the gas in °C.

(*3 marks*)

c i The original volume V_1 of gas trapped in the cylinder is 3.0×10^{-5} m^3. Atmospheric pressure p_1 is 1.0×10^5 Pa.

Show that the amount of gas in the cylinder is about 1×10^{-3} mol.

(*2 marks*)

ii The molar mass, M, of the gas is 0.016 kg mol^{-1}.

Calculate the mass, m, of gas, in kg, present in the cylinder.

(*1 mark*)

iii During the initial heating process all of the heat supplied to the gas is converted into kinetic energy of the gas molecules. Calculate the increase in the internal energy of the gas during that process.

Specific heat capacity of the gas = 1300 J kg^{-1} K^{-1}

(*2 marks*)

Refer to the Physics A datasheet for data, formulae and relationships information.

Section A

1 The graph shows the cooling curve for a molten wax.

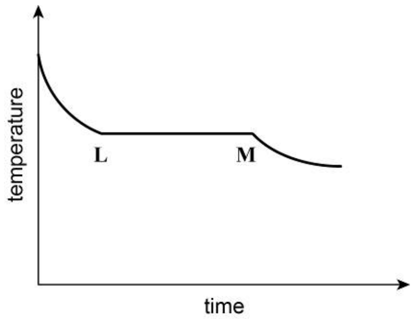

Figure 1

There is no change in temperature between the points **L** and **M** because:

A The wax only loses energy while the temperature falls.

B When the wax changes state, latent heat is the source of the energy lost.

C The wax absorbs energy when solidifying.

D The specific heat capacity of the wax changes during solidification.

Your answer ☐ (*1 mark*)

2 In an experiment to demonstrate Brownian motion in a liquid, pollen grains are observed with a microscope. Which of the following statements is/are a correct explanation of the observations?

1 The motion of the pollen grains is random because of random changes in the number of liquid molecules hitting the pollen.

2 The molecules of the liquid have a random distribution of speeds.

3 The mass of the pollen grains is much greater than the mass of the molecules.

A 1 only

B 1 and 2

C 1 and 3

D 3 only

Your answer ☐ (*1 mark*)

3 An ideal gas at a pressure, P, and temperature, T, contains N molecules per unit volume. The pressure of the gas is increased to $2P$ and the temperature is reduced to $0.5T$. What does the number of molecules per unit volume now become?

A $0.5N$

B N

C $0.25N$

D $4N$

Your answer ☐ (*1 mark*)

4 A mechanical system is forced to vibrate by an external oscillator. There is minimal damping in the system. Which of the following statements is true at resonance?

1 The amplitude of the vibration is a maximum.

2 The driving frequency of the oscillator is equal to the natural frequency of the system.

3 The energy transferred from the oscillator to the system is a maximum.

A 1, 2, and 3

B 1 and 2

C 1 and 3

D 2 only

Your answer ☐ (*1 mark*)

5 Two satellites, **K** and **L**, travel in circular orbits of radii 8000 km and 12 000 km, respectively, around the centre of the Earth.

What is the value of the ratio $\dfrac{\text{periodic time for } \mathbf{K}}{\text{periodic time for } \mathbf{L}}$?

A $\dfrac{2}{3}$

B $\left(\dfrac{2}{3}\right)^{1.5}$

C $\left(\dfrac{2}{3}\right)^{\frac{2}{3}}$

D $(1.5)^{1.5}$

Your answer ☐ (*1 mark*)

6 Dark lines are seen in the Sun's spectrum.

What are these dark lines caused by?

A interference between light from different points on the sun's surface
b diffraction of light as it travels from the Sun to the Earth
C absorption of certain frequencies by gases in the outer layers of the Sun
D atoms in the Sun's surface emitting intense light at certain frequencies

Your answer ☐ (*1 mark*)

7 The Hertzsprung–Russell diagram **directly** compares which two properties of stars?

A size and temperature
B luminosity and temperature
C size and distance
D luminosity and surface area

Your answer ☐ (*1 mark*)

8 Two springs, **X** and **Y**, both obey Hooke's law. They have force constants of magnitude $2k$ and k, respectively.

The springs are each stretched by a force that is gradually increased from zero up to an identical maximum value. The work done in stretching spring **X** is W_X, and the work done in stretching spring **Y** is W_Y.

Which formula correctly relates W_X and W_Y?

A $W_X = 0.25\,W_Y$
B $W_X = 0.5\,W_Y$
C $W_X = 2\,W_Y$
D $W_X = 4\,W_Y$

Your answer ☐ (*1 mark*)

9 A beam of monochromatic light of wavelength 550 nm is incident normally on a diffraction grating. The angle between the two second-order diffracted beams is 45°.

What is the grating spacing?

A 2.9 μm
B 1.6μm
C 1.4 μm
D 0.78 μm

Your answer ☐ (*1 mark*)

10 A star has surface temperature 3200 °C and luminosity L. A second star of identical size has a surface temperature of 2700 °C.

What is the luminosity of the second star expressed in terms of L?

A 0.51 L
B 0.84 L
C 1.9 L
D 0.54 L

Your answer ☐ (*1 mark*)

Section B

11 a The average intensity of solar radiation incident on a solar panel is 250 W m^{-2}. The solar panel uses this radiation to heat water flowing through it. The rate of flow of water through the panel is kept constant at 5.0×10^{-4} m^3 min^{-1}. A single solar panel has an area of 4.0 m^2 and 80% of the solar radiation is used to heat the water.

Calculate the temperature rise of the water as it flows through the panel.

Specific heat capacity of water = 4200 J kg^{-1} K^{-1}

....

....

....

.... (*4 marks*)

b A group of scientists have formulated an organic liquid to be used in a heat exchanger. They now need to determine the specific heat capacity of the liquid.

Write a plan describing how they could do this in a laboratory.

You should include:

- a labelled diagram of the arrangement
- a list of the measurements to be taken
- an explanation of how the value of c would be determined from your results
- possible sources of uncertainty in your measurements and how these could be reduced.

....

....

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....

.... (*6 marks*)

12 a A gas molecule of mass m travelling perpendicular to the wall of a container hits the wall with speed v. Explain why the molecule rebounds with speed v and determine the change of momentum experienced by the molecule.

....

.... (*2 marks*)

b A constant mass of gas occupies a container of constant volume. Use the kinetic theory of gases to explain the increase in the force exerted on the walls of the container by the gas when its temperature is raised.

....

....

.... (*3 marks*)

c **i** The tyres of a car are pumped up with air to a pressure 2.1×10^5 Pa at 17 °C before a journey. After completing the journey, the temperature of the air in the tyres rises to 59 °C.

Calculate the new pressure of the air. Assume the volume of the tyres remains unchanged.

....

.... (*2 marks*)

ii Assuming that the total mass of the car in **i** stays constant at 1800 kg, calculate the change in the total area of contact of the tyres with the road as a result of the rise in temperature.

....

....

.... (*3 marks*)

Based on OCR Physics A, June 2013

13 a Figure 2 shows a Griffin search helicopter viewed from above.

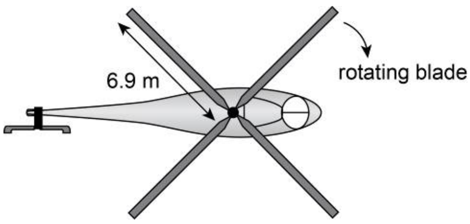

Figure 2

The blades of the helicopter rotate in a circle of radius 6.9 m. When the helicopter is hovering, the blades propel air vertically downwards with a constant speed of 16 m s^{-1}. Assume that the descending air occupies a uniform cylinder of radius 6.9 m.

Density of air is 1.3 kg m^{-3}

i Show that the mass of air propelled downwards in a time of one minute is about 2×10^5 kg.

....

.... (*2 marks*)

ii Calculate the force provided by the rotating helicopter blades to propel this air downwards.

....

....

.... (*3 marks*)

iii State, in relation to this situation, the law you have used to determine the answer to **ii**.

.... (*1 mark*)

iv Calculate the mass of the hovering helicopter. Explain your reasoning.

....

.... (*2 marks*)

b Figure 3 shows an aeroplane flying in a horizontal circle at constant speed. The weight of the aeroplane is W and the lift force acting at right angles to the wings is L.

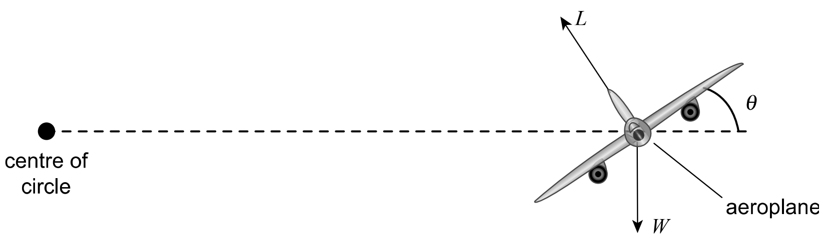

Figure 3

i Explain how the lift force, L, keeps the aeroplane flying in a horizontal circle.

....

.... (*2 marks*)

ii Explain how the aeroplane is able to fly at constant speed even though there is a resultant force acting upon it.

....

.... (*2 marks*)

iii The aeroplane flies in a horizontal circle at a constant speed of 220 m s^{-1}. The wings of the aeroplane are kept at an angle of 25° to the horizontal throughout.

Calculate the radius of the circle.

....

....

....

.... (*4 marks*)

Based on OCR Physics A, January 2011

14 a A body vibrates with simple harmonic motion about its equilibrium position.

Describe the difference between:

i **displacement** and **amplitude**

....

.... (*2 marks*)

ii **frequency** and **angular frequency.**

....

.... (*2 marks*)

b Figure 4 shows the cross section of a dockyard basin. The sides of the basin are vertical and the bottom is flat. The tide causes the surface of the water to perform vertical simple harmonic motion (SHM). The period of the SHM is 12.5 hours. The surface of the water in the basin is calm throughout the oscillation.

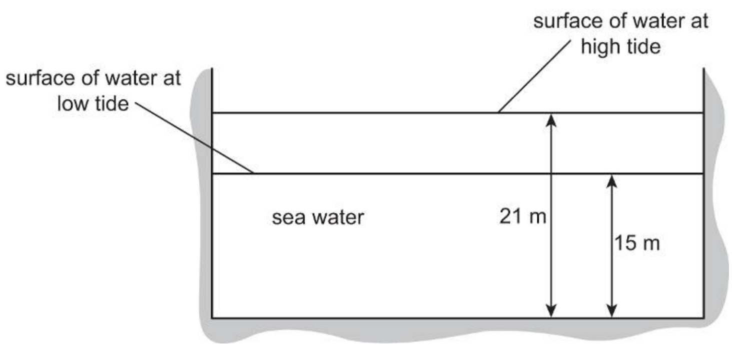

Figure 4

The maximum depth of the water is 21 m and the minimum depth is 15 m.

i Calculate the amplitude of the water oscillation.

.... (*1 mark*)

ii Calculate the frequency of the water oscillation.

....

.... (*2 marks*)

iii Calculate the maximum vertical speed of the water surface.

....

.... (*2 marks*)

iv Write an expression for the depth of water, d, in metres, present in the basin in terms of time, t, in seconds.

....

.... (*2 marks*)

OCR Physics A, January 2011

15 a A planet of mass, m, moves in a circular orbit of radius, r, about a star of mass, M. The planet has an orbital period, T.

Use your knowledge of circular motion and Newton's law of gravitation to derive an equation representing Kepler's third law.

....

....

....

.... (*4 marks*)

b S. Synnott used data from the Voyager 1 spacecraft to identify the Amalthea group of moons orbiting Jupiter. Table 1 gives part of the data for two of these moons.

Name	Mean orbital radius/10^8 m	Orbital period/hour
Metis	1.28	7.08
Thebe	2.22	

Table 1

i Calculate the speed of Metis in its orbit.

....

.... (*2 marks*)

ii Show that the mass of Jupiter is about 2×10^{27} kg.

....

.... (*2 marks*)

iii Complete the data table by determining the orbital period of Thebe.

....

.... (*2 marks*)

OCR Physics A, June 2010

16 a Figure 5 shows how the recessional speed, v, of galaxies varies with their distance, d, from the Earth.

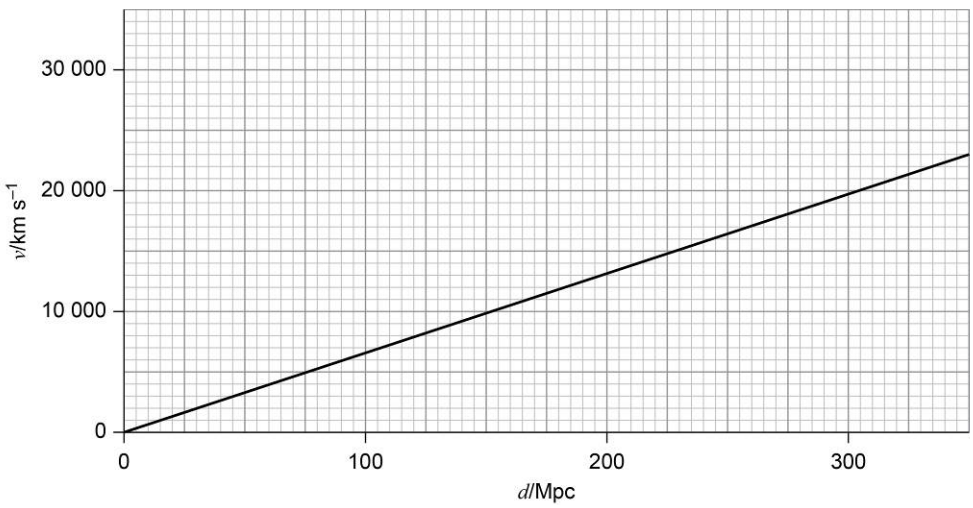

Figure 5

i Use Figure 5 to determine the value of the Hubble constant.

....

.... (*2 marks*)

ii Hence, estimate the age of the Universe in years.
1 year = 3.2×10^{7} s and 1 pc = 3.1×10^{16} m

....

....

.... (*3 marks*)

b Describe the evidence for the Big Bang model of the Universe.

....

....

....

....

....

....

....

.... (*6 marks*)

Refer to the Physics A datasheet for data, formulae and relationships information.

1 **a** Define *simple harmonic motion.*

....

....

....

.... (*2 marks*)

b Figure 1 shows a mass hanging on a spring. When the mass is pulled down and then released, it oscillates with simple harmonic motion. The position of the mass can be determined using the metre rule mounted alongside the spring. Figure 2 shows the variation of this position with time. The mass was released at time $t = 0$ s.

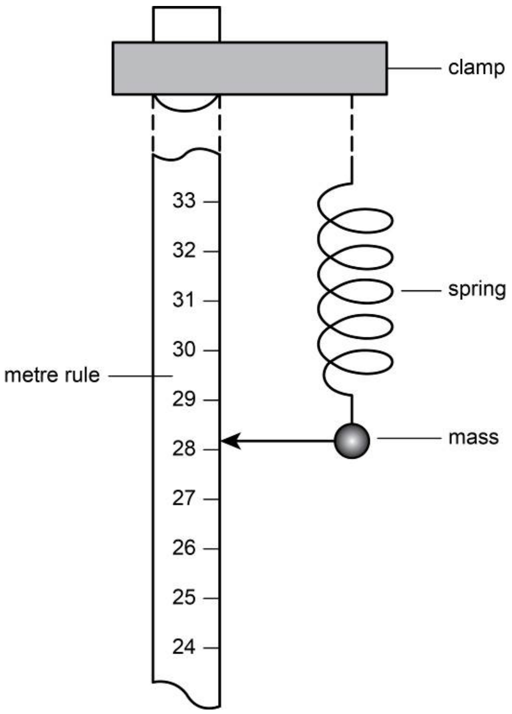

Figure 1

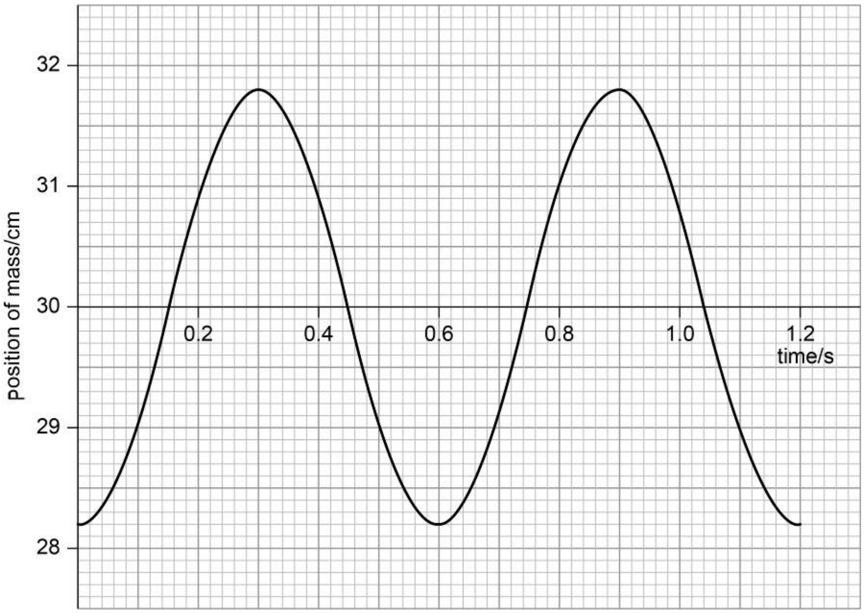

Figure 2

i Use Figure 2 to determine:

1 the frequency of the oscillation

2 the amplitude of the oscillation.

....

....

.... (*3 marks*)

ii Calculate the maximum acceleration experienced by the mass and state the position of the mass at the time when this occurs.

....

....

.... (*3 marks*)

iii Use Figure 2 to state two times at which the mass has maximum speed.

.... (*1 mark*)

c On the axes of Figure 3, sketch the variation with time, t, of the acceleration, a, of the mass. Add a suitable scale on the y-axis.

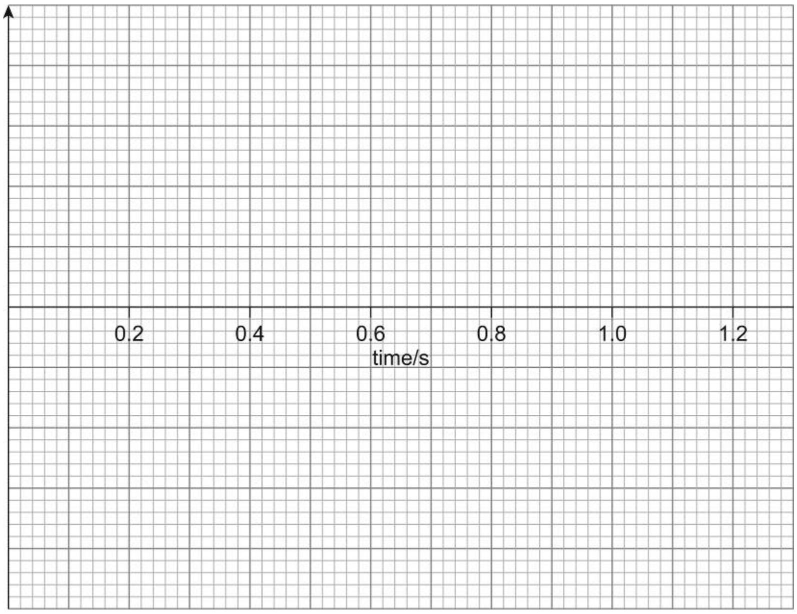

Figure 3

(*3 marks*)

2 Figure 4 shows a glider of mass 0.30 kg on a linear air track. The glider is held by two identical stretched springs. When the glider is pulled 6.0 cm to the right and then released, it oscillates freely without friction.

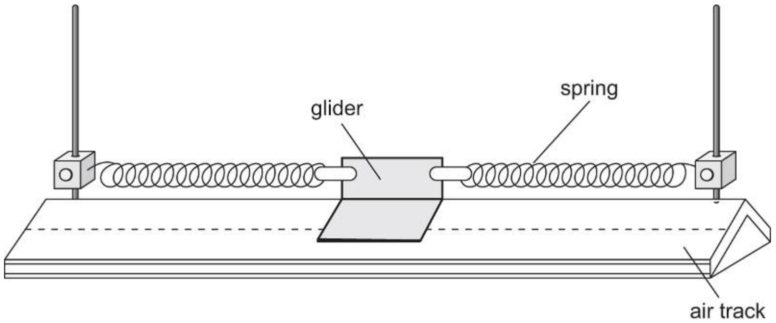

Figure 4

Figure 5 shows the variation of the elastic strain energy stored in the springs with the displacement, x, of the glider from its equilibrium position. The elastic strain energy stored in the springs when the glider is not oscillating is 50 mJ.

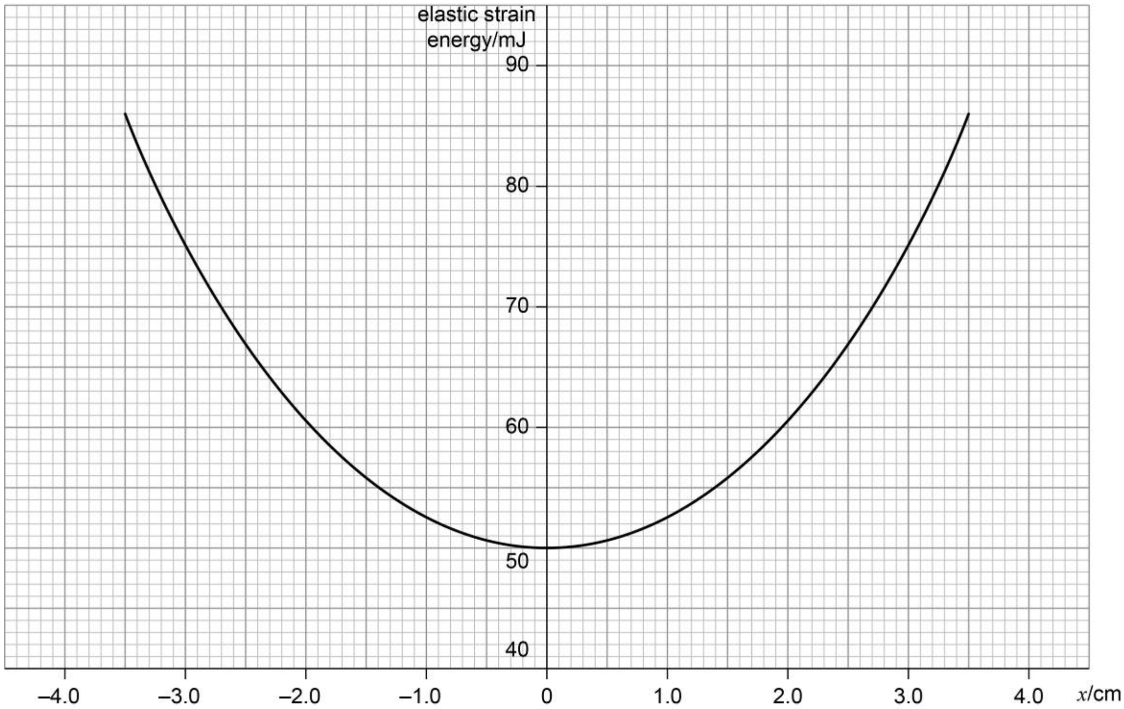

Figure 5

a State:

i the total energy stored in the system when the glider is oscillating ....

(*1 mark*)

ii the maximum kinetic energy of the glider. ....

....

(*2 marks*)

b i Show that the glider has a maximum speed of about $0.49\,\mathrm{m\,s^{-1}}$. ....

....

(*2 marks*)

ii Use Figure 5 to determine the amplitude of the oscillations required to halve the maximum speed of the glider. Show your reasoning. ....

....

(*2 marks*)

3 Figure 6 shows a mass attached to the end of a spring. The mass is pulled down and then released. The mass performs vertical simple harmonic motion.

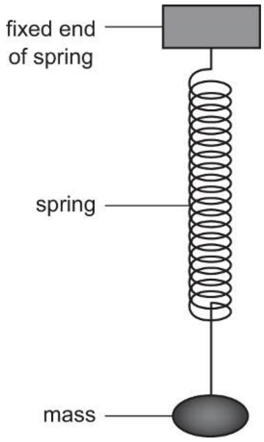

Figure 6

a Mark the following statements about the oscillating mass−spring system as **true** or **false**.

Statement	True/False
The period of the oscillations is constant	
The velocity of the mass is proportional to the displacement	
The net force on the mass is equal to the weight	
The acceleration of the mass is a maximum at the midpoint of the oscillations	

(*2 marks*)

b A student wishes to investigate whether the period of oscillation of a simple pendulum is constant for all angles of swing.

Describe how the student should carry out the investigation.

Include the following in your description:

- a diagram of the apparatus with angle of swing labelled
- details of how the measurements would be made
- how these results would be used to form a conclusion
- the major difficulty likely to be encountered and how this might be overcome.

....

....

....

....

.... (*5 marks*)

OCR Physics A, June 2011

4 A mass is attached to the end of a spring, which hangs from a rigid support. The mass is pulled down and then released. The mass oscillates vertically about its equilibrium position.

Figure 7 shows the graph of the acceleration, a, of the mass against its displacement, x, from its equilibrium position.

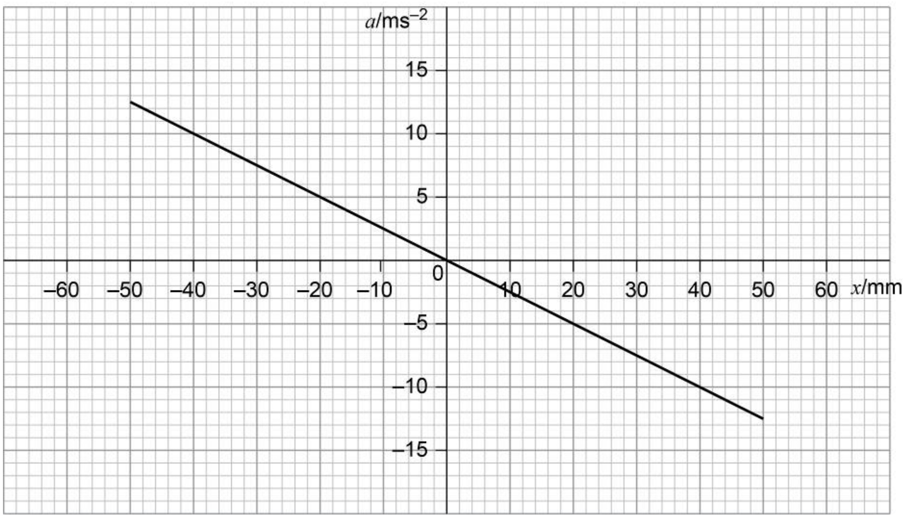

Figure 7

a Explain how the graph shows that the object is oscillating with simple harmonic motion.

....

....

....

.... (*2 marks*)

b Use data from the graph to:

i find the amplitude of the motion (1 mark)

ii show that the period of oscillation is 0.4 s.

(*3 marks*)

c i The mass is released at time, $t = 0$, with a displacement, $x = 0.050$ m. Sketch a graph on the axes of Figure 8 to show how the displacement of the mass varies between $t = 0$ and $t = 1.0$ s. Add suitable scales to both axes.

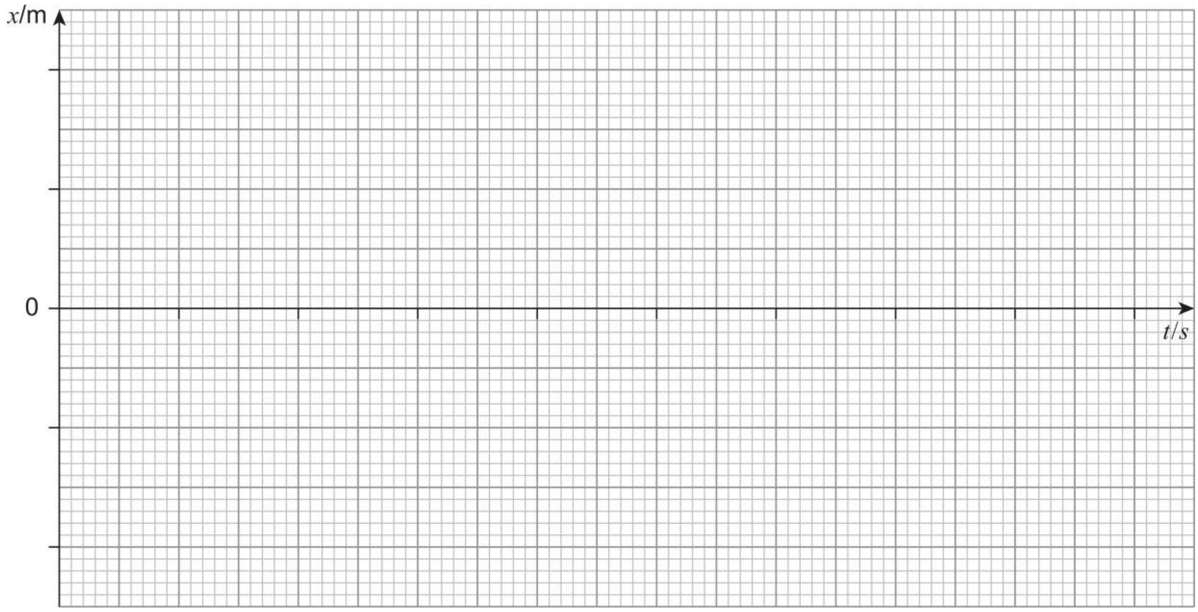

Figure 8

(*3 marks*)

ii State a displacement and time at which the system has maximum kinetic energy.

(*2 marks*)

OCR Physics A, January 2005

5 Figure 9 shows a mass attached to two springs. The mass moves along a horizontal tube with one spring stretched and the other compressed. An arrow marked on the mass indicates its position on a scale. Figure 9 shows the situation when the mass is displaced through a distance, x, from its equilibrium position. The mass is experiencing an acceleration, a, in the direction shown. Figure 10 shows a graph of the **magnitude** of the acceleration, a, against the displacement, x.

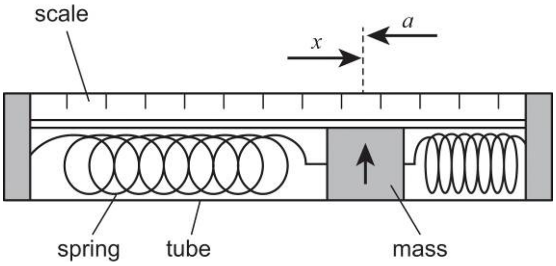

Figure 9

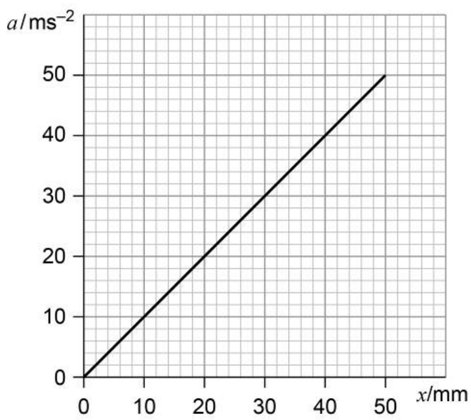

Figure 10

a State **one** feature from each of Figure 9 and 10 which shows that the mass performs simple harmonic motion when released.

....

.... (*2 marks*)

b Use data from Figure 10 to show that the frequency of the simple harmonic oscillations of the mass is about 5 Hz.

....

....

.... (*3 marks*)

c The mass oscillates in damped harmonic motion before coming to rest. On the axes of Figure 11, sketch a graph of the damped harmonic oscillation of the mass, from an initial displacement of 25.0 mm.

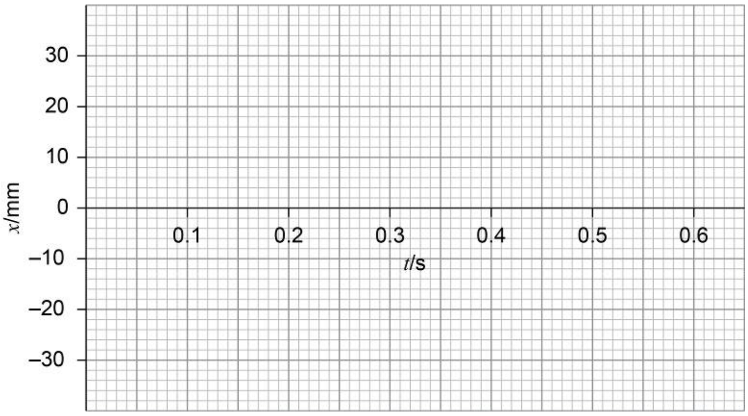

Figure 11

(*3 marks*)

OCR Physics A, January 2006

6 **a** State two conditions concerning the acceleration of an object that apply when it is in simple harmonic motion.

....

....

.... (*2 marks*)

b Figure 12 shows how the potential energy, in mJ, of a simple harmonic oscillator varies with displacement.

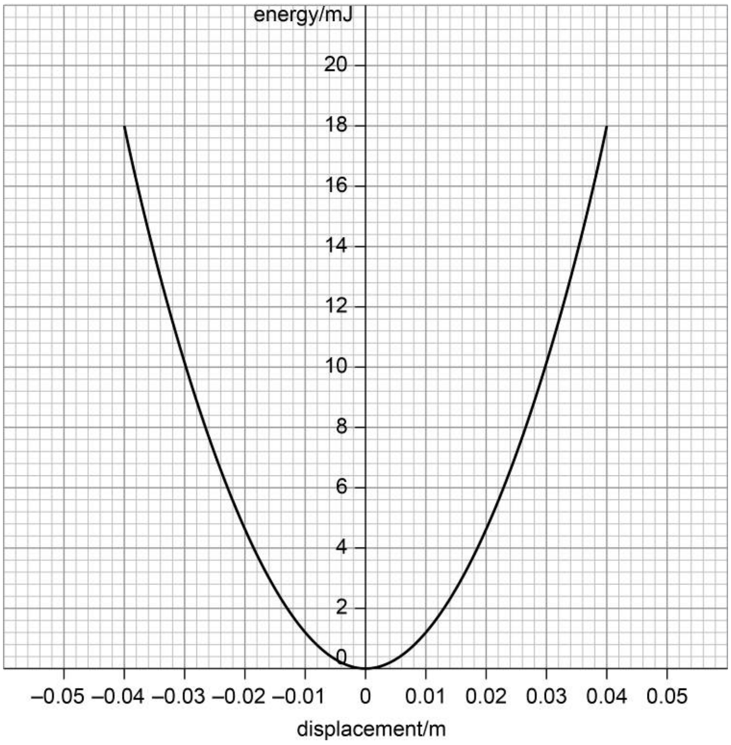

Figure 12

On Figure 12, sketch graphs to show the variation of:

i kinetic energy of the oscillator with displacement – label this graph **K**

(*2 marks*)

ii the total energy of the oscillator with displacement – label this graph **T**.

(*1 mark*)

c Use Figure 12 to determine:

i the amplitude of the oscillations ....

(*1 mark*)

ii the maximum speed of the oscillator of mass 0.12 kg ....

....

(*2 marks*)

iii the frequency of the oscillations. ....

....

(*2 marks*)

d Resonance can either be useful or a problem. Describe **one** example where resonance has a useful application and **one** example where resonance is a problem or nuisance.

For each example, identify what is oscillating and what causes these oscillations.

i a useful application ....

.... (*2 marks*)

ii a problem ....

....

.... (*2 marks*)

OCR Physics A, June 2010

Refer to the Physics A data sheet for data, formulae and relationships information.

1 **a** The solar system consists of planets, with their attendant moons, and dwarf planets orbiting the Sun. State two other types of body that orbit our Sun and describe two features which distinguish them from each other.

....

....

....

.... (*4 marks*)

b The Sun is a main sequence star of average mass. Describe the way in which the Sun was formed and its most probable future evolution.

....

....

....

....

....

.... (*6 marks*)

2 Antares is a red supergiant star in the constellation Scorpius.

a **i** Describe three characteristics of a red supergiant star.

....

....

.... (*3 marks*)

ii State what is meant by a *constellation*.

.... (*1 mark*)

b The future evolution of Antares will be very different from that of our own Sun.

Describe how you would expect Antares to evolve.

....

....

....

.... (*4 marks*)

3 Figure 1 is an outline of the Hertzsprung–Russell (H–R) diagram.

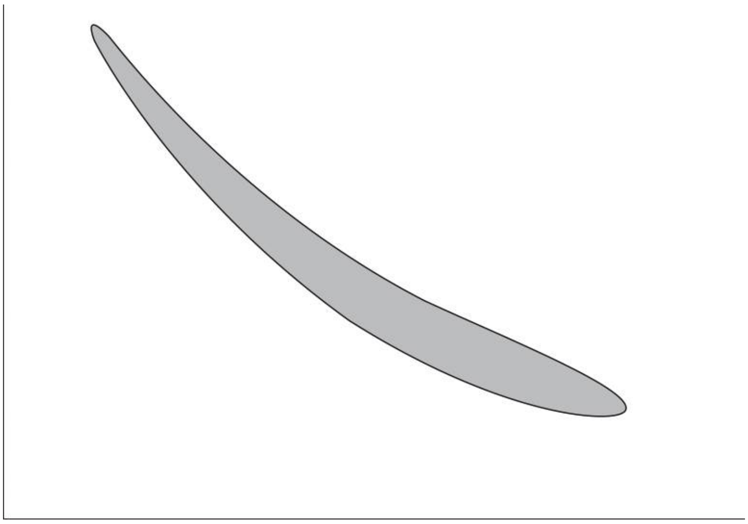

Figure 1

a On Figure 1:

i label the axes and draw arrows to indicate the directions of increasing values

(*2 marks*)

ii name the region which is shaded

.... (*1 mark*)

iii mark the approximate position that currently represents the Sun. Label this point **S**.

(*2 marks*)

b Also on Figure 1:

i mark and name positions in two other regions that the Sun is expected to occupy in the future. (*4 marks*)

ii draw a line showing the path that the Sun is expected to take over the next 5×10^9 years. (*2 marks*)

c Explain what is likely to be the final fate of the Sun.

....

.... (*2 marks*)

OCR Physics A, Jan 2010

4 a A diffraction grating is used to analyse the visible light emitted by a lamp containing hydrogen. A narrow beam of light is incident normally on the grating. The first-order spectrum of the diffracted light includes red and blue rays which emerge symmetrically from the grating, as shown in Figure 2.

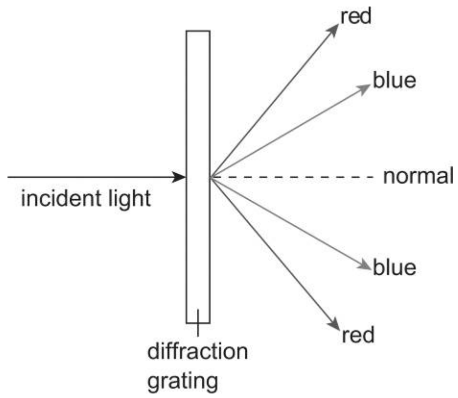

Figure 2

The angle between the two blue rays is 30.2° and the angle between the two red rays is 46.4°.

The grating has 600 lines/mm.

Show that the wavelength of the blue light is 434 nm and that of the red light is 656 nm.

....

....

.... (*3 marks*)

b The diffraction grating in **a** is used to analyse the light emitted by the Sun. It is observed that its continuous spectrum is crossed by a series of dark lines, two of which correspond to the wavelengths determined in **a**. Describe how these dark lines are produced in the solar spectrum.

(*5 marks*)

5 a Figure 3 shows the lowest four energy levels of electrons in a hydrogen atom. Excited atoms of hydrogen can emit light of specific wavelengths when electrons 'fall' to lower energy levels.

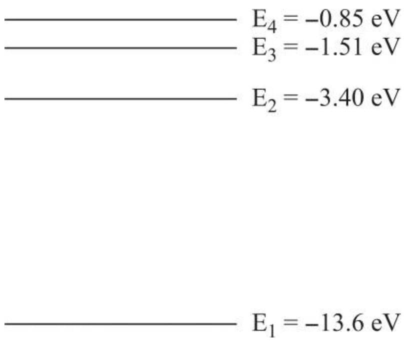

Figure 3

i Determine the wavelength which corresponds to transitions between the E_3 and E_2 levels.

(*3 marks*)

ii The transition from E_3 to E_2 gives light in the visible part of the spectrum. Without calculation, suggest in which region of the spectrum you would expect to detect photons emitted when electrons transfer from the E_3 to E_1 level. Make your reasoning clear in your answer.

(*2 marks*)

b Figure 4 shows the black-body radiation curves for three stars labelled **A**, **B** and **C**.

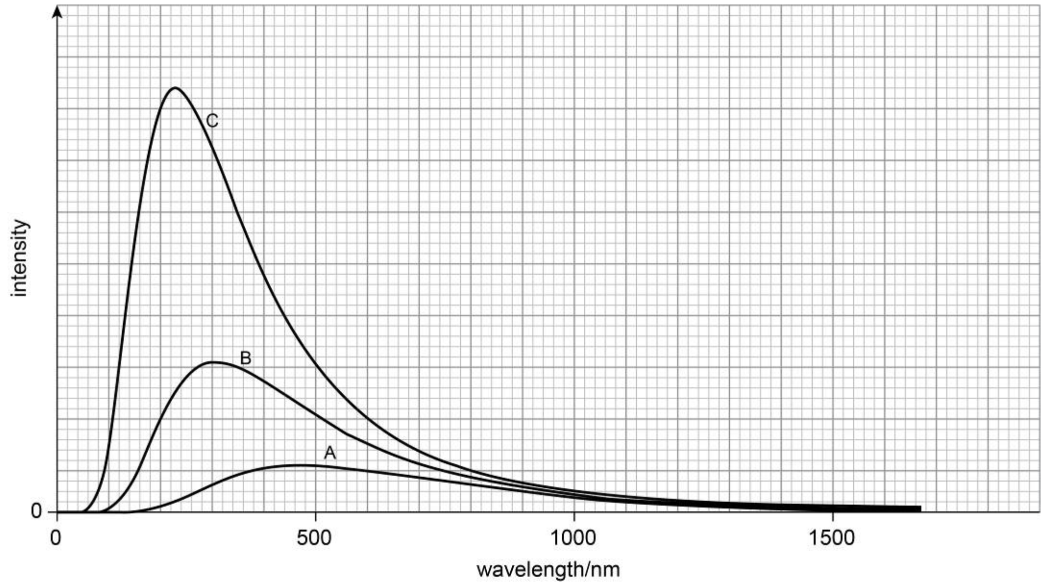

Figure 4

i State and explain, without calculation, which one of the three stars is the coolest.

....

.... (*2 marks*)

ii Calculate the black body temperature of star **B**.

Wien's constant = 2.9×10^{-3} m K

....

....

.... (*3 marks*)

6 Rigel is the brightest star in the constellation Orion and the seventh brightest star in the night sky.

a The black-body radiation curve for Rigel shows a peak at a wavelength of 241 nm. Calculate the black-body temperature of Rigel.

Wien's constant = 2.9×10^{-3} m K

....

.... (*2 marks*)

b The luminosity of Rigel is 120 000 times greater than the Sun.
Use Stefan's law to calculate the radius of Rigel.
Luminosity of the Sun = 3.85×10^{26} W
Stefan's constant = 5.67×10^{-8} W m^{-2} K^{-4}

....

....

....

.... (*3 marks*)

c Explain how the spectrum obtained from Rigel can be used to give information about its composition.

....

....

....

.... (*4 marks*)

Refer to the Physics A data sheet for data, formulae and relationships information.

1 **a** Use the kinetic theory of matter to relate the properties of the solid, liquid, and gaseous phases of a substance, to the forces and distance between its molecules and to the motion of its molecules.

....

....

....

....

....

.... (*6 marks*)

b A block of aluminium at 80 ºC is fully immersed in a beaker of water at 290 K. Describe the transfer of thermal energy between the three objects involved and any change in temperature that may take place.

....

....

....

.... (*4 marks*)

2 Gallium has a melting point of 30 ºC. Figure 1 shows how the temperature, T, of a small mass of gallium varies when it is heated at a steady rate from 20 ºC to 40 ºC.

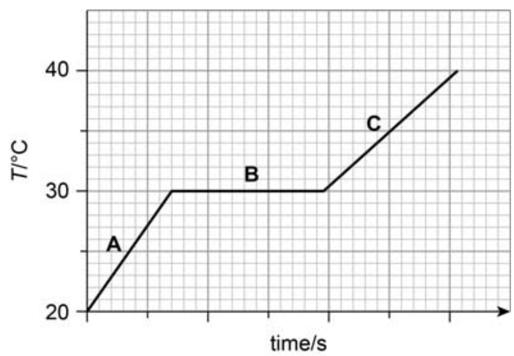

Figure 1

The graph shows three distinct sections labelled **A**, **B**, and **C**.

Describe and explain the features of the graph in terms of the changes which occur to the separation and speed of the molecules and to their internal energy.

....

....

....

....

....

....

.... (*7 marks*)

3 **a** Define the **specific heat capacity** of a substance.

....

.... (*1 mark*)

b The specific heat capacity of a metal may be determined by using an electrical heater embedded into a block made out of the metal. Sketch a labelled diagram of the **electrical circuit** you would use.

(*3 marks*)

c The pitch in a football stadium is prevented from freezing by an underground system of electrical heating cables. Prior to a match the pitch temperature falls to –5.5 °C to a depth of 6.0 cm. The area of the pitch is 1.3×10^4 m².

Calculate the thermal energy required to raise the temperature of the soil to 0 °C assuming the density and specific heat capacity of the soil are 2500 kg m^{-3} and 1600 J kg^{-1} K^{-1}, respectively.

....

....

.... (*3 marks*)

4 **a** Derive the SI base unit for **specific heat capacity**.

....

....

.... (*3 marks*)

b A bottle containing 500 g of lemonade is placed in a refrigerator. The lemonade cools from 18 °C to 4.0 °C in a time of 90 minutes.

The specific heat capacity of lemonade is 3900 J kg^{-1} K^{-1}.

Calculate:

i the thermal energy removed from the lemonade as it cools

....

.... (*2 marks*)

ii the rate at which thermal energy is removed from the lemonade, in watts.

.... (*1 mark*)

5 **a** Define the **specific latent heat of fusion** of a substance.

....

.... (*1 mark*)

b Describe an electrical experiment to determine the specific latent heat of vaporisation of water, L_v. Include in your answer:

- a labelled diagram of the apparatus
- a list of the measurements to be taken
- an explanation of how the value of L_v would be determined from your results
- possible sources of uncertainty in your measurements and how these could be reduced.

(*8 marks*)

6 **a** A solid substance is placed into a sealed insulated container until it vaporises. The container is heated electrically at a constant rate until the substance has completely vaporised. Figure 2 shows the temperature against time graph for the entire process.

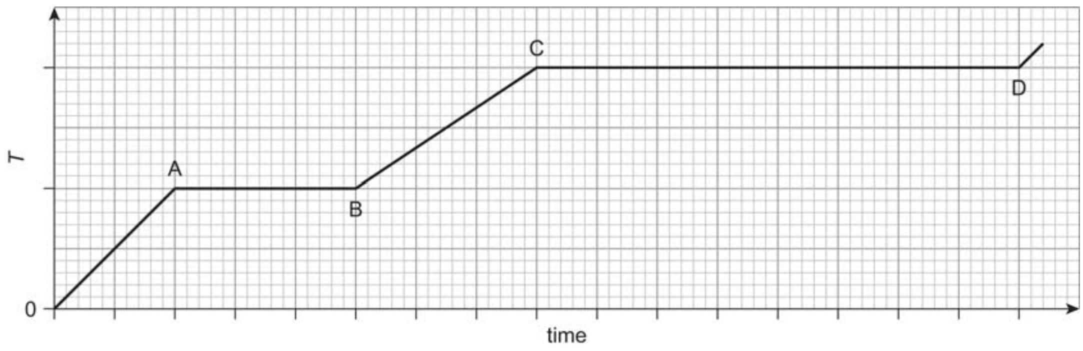

Figure 2

Use the graph to calculate for the substance:

i the ratio

$$\frac{\text{specific heat capacity of the solid phase}}{\text{specific heat capacity of the liquid phase}}$$

....

.... (*2 marks*)

ii the ratio

$$\frac{\text{specific latent heat of vaporisation}}{\text{specific latent heat of fusion}}$$

....

.... (*2 marks*)

b In an espresso coffee machine, steam at 100 °C is passed into 250 g of milk in order to heat it from 15 °C to 80 °C.

Specific heat capacity of water = 4200 J kg^{-1} K^{-1}

Specific latent heat of vaporisation of water = 2.26 × 10^{6} J kg^{-1}

Calculate the mass of steam condensed in the process.

....

....

.... (*3 marks*)

Wider reading to support your studies in Physics

Title	Author/Contributor	Topic
A Brief History of Time	Stephen Hawking	Astrophysics
The Elegant Universe	Brian Greene	Astrophysics
How to teach relativity to your dog	Chad Orzel	All
Forces of nature	Brian Cox	Forces
Smashing physics	Jon Butterworth	Particle Physics
Black bodies and quantum cats	Jennifer Ouellette	All

Useful websites to support your studies in Physics

Website	Website Link	Topic
A level physics online	https://www.alevelphysicsonline.com/	All
Institute of physics	http://www.iop.org/	All
Physics and Maths Tutor	https://www.physicsandmathstutor.com/past-papers/a-level-chemistry/	Chemistry – All modules
The Royal Society	http://royalsociety.org	All
The Scientific journal	http://nature.com	All
Nobel prize	http://nobelprize.org	All