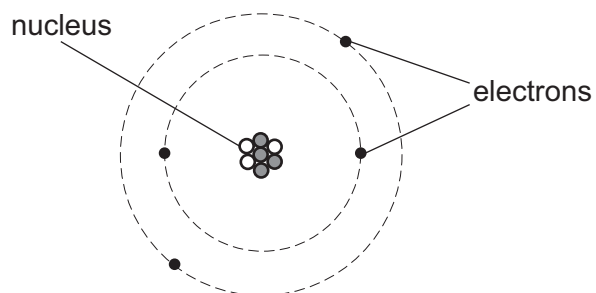
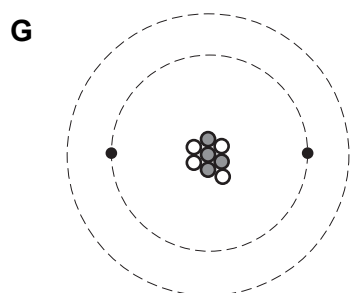
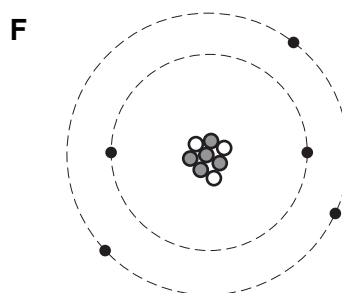
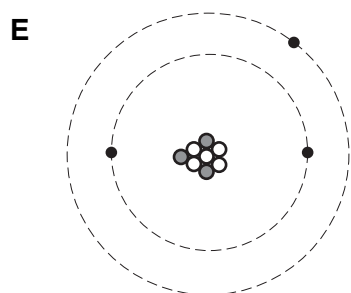
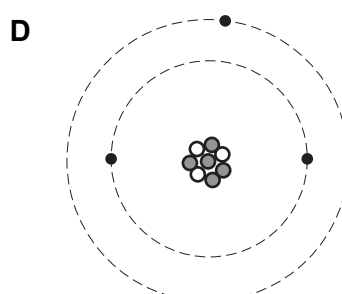
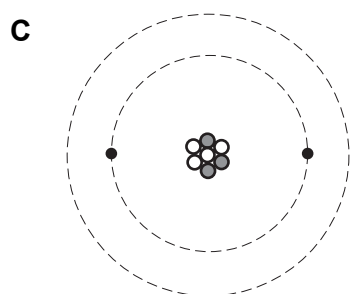
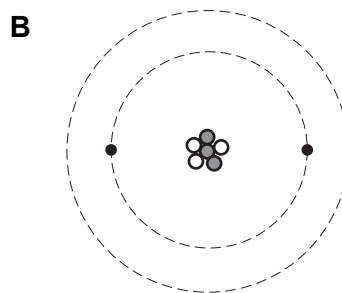
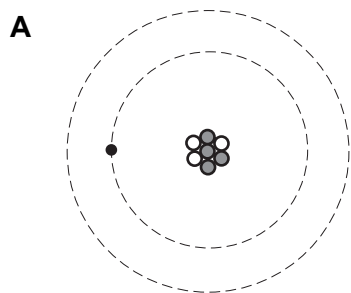


PART B Physics

- 21 The diagram represents the structure of a charged atom (ion) of one isotope of an element.



Which diagram represents the structure of an oppositely charged ion of a different isotope of the same element?



- 22** A soldering iron has a copper tip of mass 2.0 g.

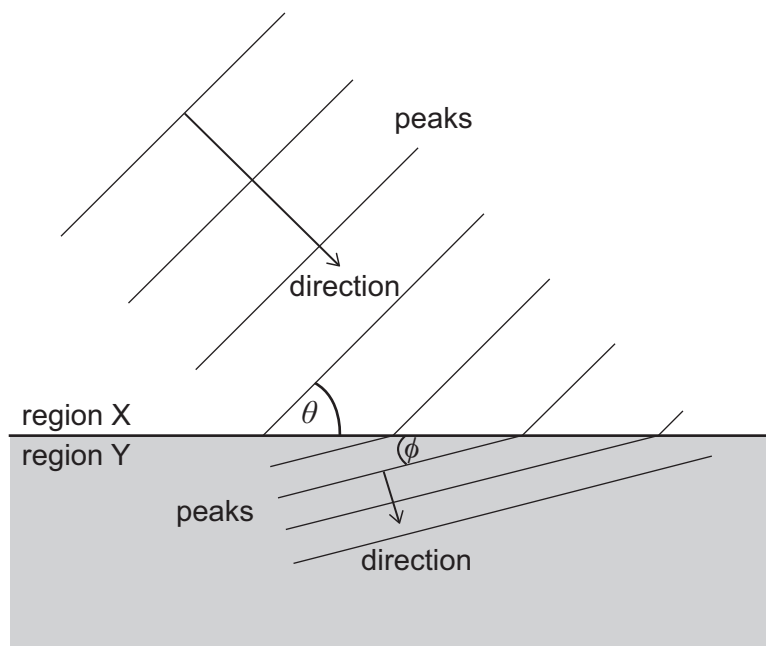
The tip is heated with 30 W of thermal power. In 50 s, the temperature of the tip increases by 200 °C.

How much energy is transferred from the tip to the surroundings in this time?

(specific heat capacity of copper = 400 J kg⁻¹ °C⁻¹)

- A** 160 J
- B** 500 J
- C** 1340 J
- D** 1500 J
- E** 1660 J
- F** 1840 J
- G** 2500 J

- 23** A water wave is travelling in a shallow tank of water. The wave passes from region X into region Y where the speed of the wave differs from that in region X. The diagram shows the directions of travel in the two regions and peaks of the wave that are separated by one wavelength.



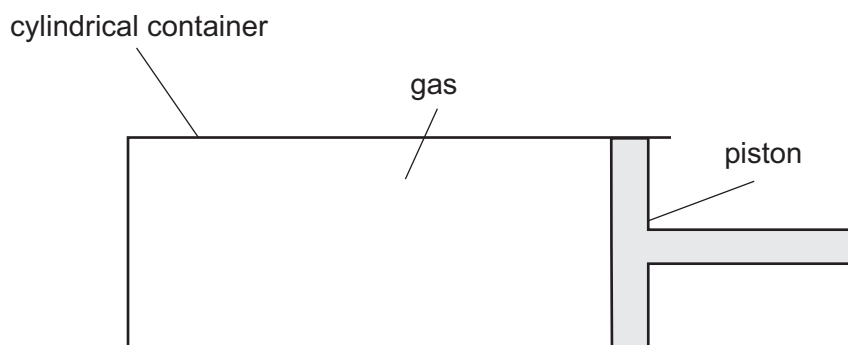
In region X, the angle between the wave peaks and the boundary between the regions is θ .

In region Y, the angle between the wave peaks and the boundary is ϕ .

What are the angle of incidence and the angle of refraction, and in which region is the speed of the wave greater?

	<i>angle of incidence</i>	<i>angle of refraction</i>	<i>speed greater in region</i>
A	θ	ϕ	X
B	θ	ϕ	Y
C	θ	$90^\circ - \phi$	X
D	θ	$90^\circ - \phi$	Y
E	$90^\circ - \theta$	ϕ	X
F	$90^\circ - \theta$	ϕ	Y
G	$90^\circ - \theta$	$90^\circ - \phi$	X
H	$90^\circ - \theta$	$90^\circ - \phi$	Y

- 24** A sample of an ideal gas is sealed in a cylindrical container by a piston as shown in the diagram.



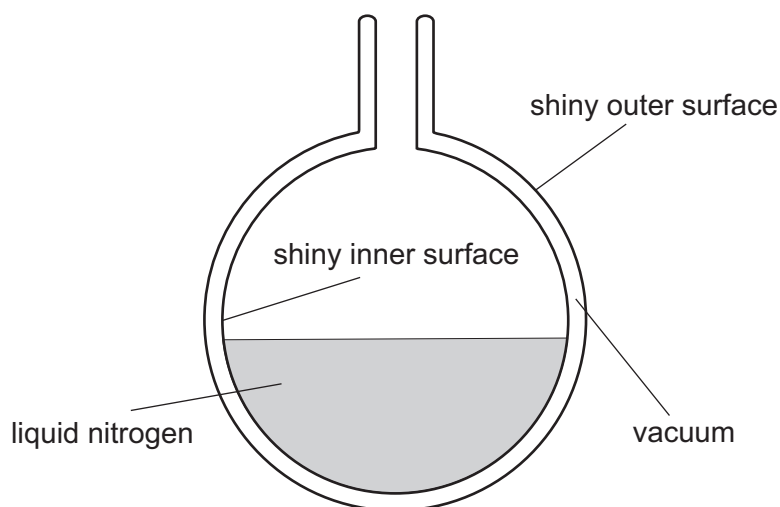
The particles of the gas are moving with an average speed v , and collide with the surface of the piston with a frequency f .

The piston is now slowly pushed into the cylinder until the gas occupies half of its original volume, but the gas remains at the same temperature.

What is the new average speed of the particles of the gas, and at what frequency do they now collide with the surface of the piston?

	<i>average speed</i>	<i>frequency</i>
A	$2v$	$\frac{1}{2}f$
B	$2v$	f
C	$2v$	$2f$
D	v	$\frac{1}{2}f$
E	v	f
F	v	$2f$

- 25** In a laboratory, liquid nitrogen is stored at a very low temperature in the vessel shown in the diagram.



The vessel has a double wall made from a poor thermal conductor. There is a vacuum in the gap between the two walls.

The inner surface of the inner wall is shiny. The outer surface of the outer wall is shiny.

These features insulate the liquid nitrogen by reducing the rate at which thermal energy is transferred to the liquid nitrogen.

Which of the following statements explain(s) why these features help to insulate the liquid nitrogen?

- 1** The shiny inner surface of the inner wall is a good emitter of thermal radiation.
 - 2** Thermal radiation cannot travel in a vacuum.
 - 3** The shiny outer surface of the outer wall is a poor absorber of radiation.
- A** none of them
- B** 1 only
- C** 2 only
- D** 3 only
- E** 1 and 2 only
- F** 1 and 3 only
- G** 2 and 3 only
- H** 1, 2 and 3

- 26** Uranium-238 ($^{238}_{92}\text{U}$) decays by a series of alpha and beta (β^-) emissions to become the stable isotope lead-206 ($^{206}_{82}\text{Pb}$).

How many beta (β^-) particles are emitted in the decay of one uranium-238 nucleus to lead-206?

- A** 6
B 8
C 10
D 12
E 14
F 16

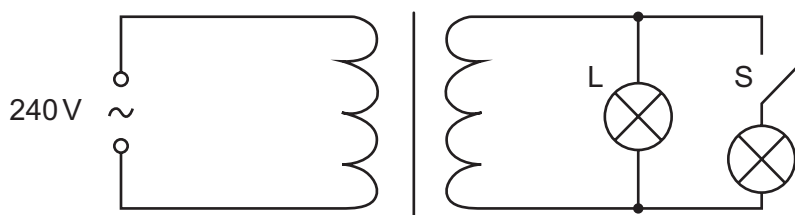
- 27** A dc electricity transmission system uses an undersea cable to send electricity from one country to another. On a particular day, the first country supplies electricity at a voltage of 400 kV and 2000 A to the transmission system. The second country receives electricity from the transmission system at 160 kV and 4000 A.

What is the percentage efficiency of the system and how much energy is wasted every minute?

	<i>efficiency %</i>	<i>energy wasted every minute / J</i>
A	20	9.6×10^9
B	20	3.84×10^{10}
C	20	4.8×10^{10}
D	80	9.6×10^9
E	80	3.84×10^{10}
F	80	4.8×10^{10}

- 28** The primary coil of an ideal, 100% efficient transformer is connected to a 240 V mains supply.

A lamp L that is connected to the secondary coil has a voltage of 12 V across it. An identical lamp and a switch S are also connected to the transformer as shown in the diagram.



With the switch open, the current in the primary coil is 0.10 A.

The switch is now closed.

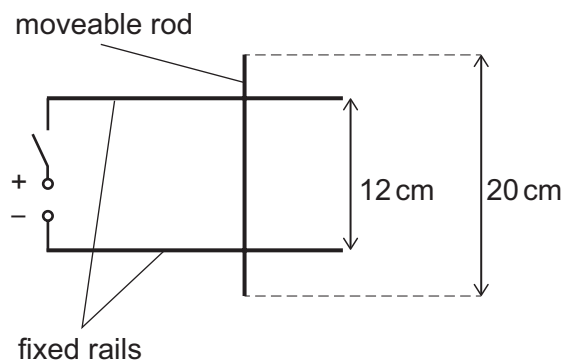
What is the current in the primary coil now and what is the current in lamp L?

	<i>current in primary coil / A</i>	<i>current in lamp L / A</i>
A	0.10	1.0
B	0.10	2.0
C	0.10	4.0
D	0.20	1.0
E	0.20	2.0
F	0.20	4.0

- 29** Two fixed horizontal metal rails are side by side and 12 cm apart. The rails are connected to a dc power supply by a switch that is initially open.

A freely moveable metal rod of length 20 cm is placed on the rails as shown in the diagram. The diagram shows the arrangement seen from above.

The angle between the rod and the rails is 90° .



The whole arrangement is placed in a uniform magnetic field of magnitude 0.50 T that is directed perpendicularly into the page.

The moveable rod has a weight of 0.40 N.

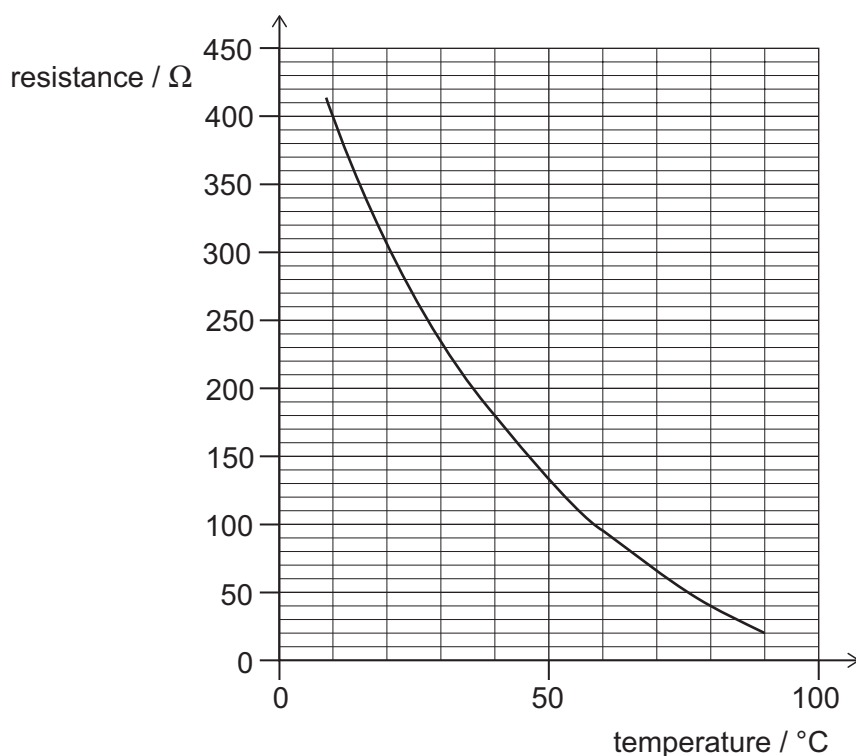
The switch is now closed. As a result, there is a current of 2.4 A in the circuit and the rod moves.

What is the initial magnitude of the acceleration of the rod and what is its direction?

(gravitational field strength = 10 N kg^{-1})

	<i>acceleration / m s^{-2}</i>	<i>direction</i>
A	0.36	to the left
B	0.36	to the right
C	0.60	to the left
D	0.60	to the right
E	3.6	to the left
F	3.6	to the right
G	6.0	to the left
H	6.0	to the right

- 30** A circuit contains a 12 V battery, a thermistor and a fixed resistor connected in series. The graph shows how the resistance of the thermistor varies with temperature.



When the temperature of the thermistor is 10°C the current in the circuit is 25 mA.

What is the current when the temperature of the thermistor is 80°C ?

- A** 30 mA
- B** 80 mA
- C** 100 mA
- D** 120 mA
- E** 150 mA
- F** 300 mA
- G** 480 mA

- 31** Two trolleys are moving towards each other along a straight horizontal track.

One trolley has mass 8.0 kg and is travelling to the right at 4.0 m s^{-1} .

The other trolley has mass 2.0 kg and is travelling to the left at 1.0 m s^{-1} .

When the trolleys collide they stick together.

How much kinetic energy is transferred to other forms of energy in the collision?

- A** 2.0 J
- B** 18 J
- C** 20 J
- D** 28 J
- E** 35 J
- F** 40 J
- G** 45 J
- H** 65 J

- 32** Visible light waves are electromagnetic waves that travel through a vacuum at $300\,000\text{ km s}^{-1}$ with wavelengths that range from 400 nm to 750 nm .

The electromagnetic waves emitted by a source are all at frequencies between $6.0 \times 10^{12}\text{ Hz}$ and $6.0 \times 10^{14}\text{ Hz}$.

Which statement about the waves emitted by the source is correct?

- A** Infrared waves are emitted, but not ultraviolet or visible light waves.
- B** Infrared and visible light waves are emitted, but not ultraviolet waves.
- C** Infrared, ultraviolet and visible light waves are all emitted.
- D** Ultraviolet waves are emitted, but not infrared or visible light waves.
- E** Ultraviolet and visible light waves are emitted, but not infrared waves.

- 33** Cubes of side 2.0 cm are tightly packed into a rectangular box with internal dimensions $12.0\text{ cm} \times 10.0\text{ cm} \times 6.0\text{ cm}$.

Each cube is either solid concrete or solid steel. There are twice as many steel cubes as concrete cubes.

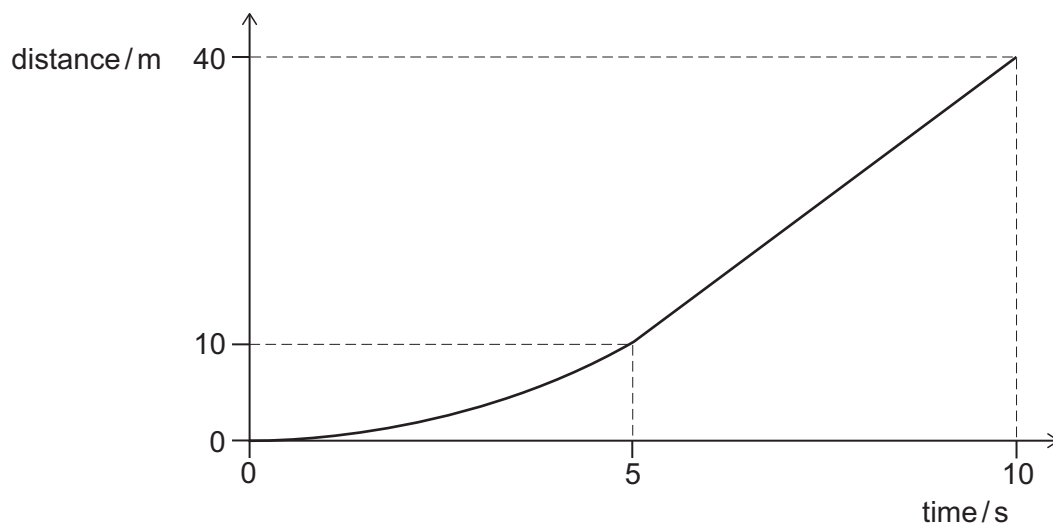
What is the total mass of the cubes in the box?

(density of concrete = 2.0 g cm^{-3} ; density of steel = 8.0 g cm^{-3})

- A** 2880 g
- B** 3240 g
- C** 3600 g
- D** 3840 g
- E** 4320 g
- F** 4800 g

- 34 A car of mass 800 kg travels in a straight line along a horizontal road.

The car accelerates **non-uniformly** from rest for 5.0 seconds and then moves at constant speed, as shown in the distance–time graph:



What is the average resultant force acting on the car over the time for which it is accelerating?

- A 320 N
- B 480 N
- C 640 N
- D 960 N
- E 1600 N
- F 3200 N
- G 4800 N

- 35** A sample contains only one radioactive isotope. This isotope decays in a single step with a half-life of 120 minutes to a stable isotope.

The sample is placed near to a radiation detector which measures the count rate. The count rate reading is 910 counts per minute (cpm).

After 240 minutes the measurement is repeated. The count rate reading is now 238 cpm.

After a further 360 minutes have elapsed, a third measurement of the count rate is made.

What is the count rate due to background radiation and what is the expected reading in the third measurement?

	<i>background count rate / cpm</i>	<i>third measurement / cpm</i>
A	224	148
B	224	226
C	142	28
D	142	148
E	142	154
F	14	14
G	14	28
H	14	42

- 36** P and Q are two fixed points on the surface of the ocean which are 6.0m apart.

An ocean wave travels in the direction P to Q.

The wave has a frequency of 0.50Hz and travels at a constant speed.

A wave peak passes Q at time $t = 0$ s.

The next wave peak travelling towards Q passes P at time $t = 0.80$ s.

What is the speed of the wave?

- A** 2.1 ms^{-1}
- B** 3.4 ms^{-1}
- C** 5.0 ms^{-1}
- D** 7.5 ms^{-1}
- E** 20 ms^{-1}

- 37** A parachutist of mass 80.0 kg drops from a plane travelling at 40.0 m s^{-1} , 2000 m above the Earth's surface.

The parachutist hits the ground at a speed of 5.00 m s^{-1} .

How much work is done by the parachutist against drag forces during the fall?

(Take the Earth's gravitational field strength to be 10.0 N kg^{-1} .)

- A** $1\,535\,000\text{ J}$
- B** $1\,624\,000\text{ J}$
- C** $1\,649\,000\text{ J}$
- D** $1\,663\,000\text{ J}$
- E** $1\,726\,000\text{ J}$

- 38** A solid uniform sphere is made of metal of density ρ_s and has radius r and volume V . It falls vertically through a viscous liquid of density ρ_L .

Three forces act on it: its weight, a drag force D and an upthrust U . The magnitude of the upthrust force is equal to the weight of the liquid displaced by the sphere.

The magnitude of the drag force is given by:

$$D = kr\upsilon$$

where υ is the speed of the metal sphere and k is a constant.

What is the terminal speed of the metal sphere as it falls through this liquid?

(gravitational field strength = g)

- A** $\frac{\rho_L g}{Vrk}$
- B** $\frac{\rho_s g}{Vrk}$
- C** $\frac{g(\rho_s - \rho_L)}{Vrk}$
- D** $\frac{g(\rho_s + \rho_L)}{Vrk}$
- E** $\frac{V\rho_L g}{rk}$
- F** $\frac{V\rho_s g}{rk}$
- G** $\frac{Vg(\rho_s - \rho_L)}{rk}$
- H** $\frac{Vg(\rho_s + \rho_L)}{rk}$

- 39** A rocket travelling in space is burning its fuel at a constant rate. By expelling the burnt fuel through a nozzle, the engine is applying a constant force to the rocket.

What is happening to the magnitude of the acceleration of the rocket?

- A** It is increasing at an increasing rate.
- B** It is increasing at a constant rate.
- C** It is increasing at a decreasing rate.
- D** It is not changing.
- E** It is decreasing at an increasing rate.
- F** It is decreasing at a constant rate.
- G** It is decreasing at a decreasing rate.

- 40** A light spring of unstretched length 0.10 m has a spring constant of 20 N m^{-1} . The spring is suspended so that it is vertical and a load of mass 0.050 kg is attached to the end of the spring.

The load is pulled vertically downwards until the length of the spring is 0.30 m. The load is then released.

What is the speed of the load at the instant that the spring returns to its unstretched length?

(gravitational field strength = 10 N kg^{-1} ; assume that resistive forces are negligible)

- A** 0 m s^{-1}
- B** 4.0 m s^{-1}
- C** 6.0 m s^{-1}
- D** 12 m s^{-1}
- E** 16 m s^{-1}
- F** $\sqrt{6} \text{ m s}^{-1}$
- G** $\sqrt{12} \text{ m s}^{-1}$
- H** $\sqrt{30} \text{ m s}^{-1}$

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