RAFFLES INSTITUTION

2021 YEAR 6 JULY COMMON TEST

29 June 2021 Time: 2 hr 30 min

H2 PHYSICS

Section A

INSTRUCTIONS TO CANDIDATES

There are 2 sections in this paper.

Section A consists of 20 multiple-choice questions. For each question, there are four possible answers **A**, **B**, **C** and **D**. Choose the one you consider correct and record your choice in soft pencil on the separate Optical Mark Sheet.

You are advised to attempt Section A first. The Optical Mark Sheets will be collected after the first **40** minutes.

Section B consists of **6** structured questions and **1** data analysis question. You are to write your answers in the spaces provided.

Attempt ALL questions in Sections A and B.

There are 10 printed pages, inclusive of the cover page and data & formulae page, in this booklet.

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}
		=	$(1/(36\pi)) \times 10^{-9}$ 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} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	$T\ /\ ^\circ\text{C} + 273.15$
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	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\ln 2 / t_{1/2}$

1 The following statements concern two systems in thermal contact with each other.

Which of them is not equivalent to the rest?

A The two systems are at the same temperature.

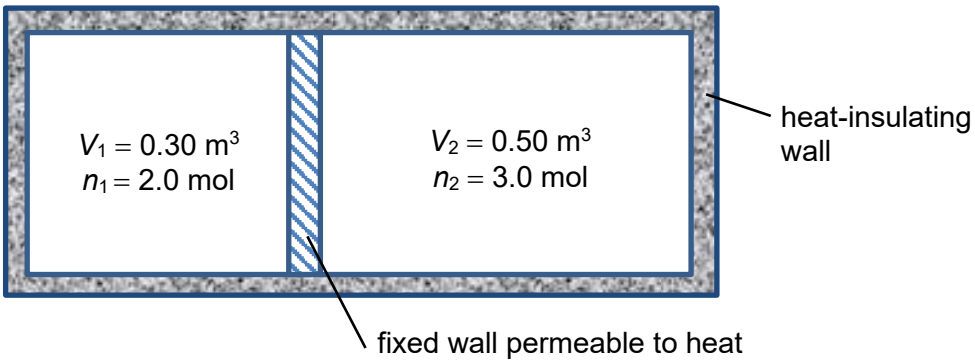
B The two systems are in thermal equilibrium with each other.

C The molecules of the two systems have the same mean speed.

D The molecules of the two systems have the same mean kinetic energy.

2 A heat-insulating container is divided into two compartments, of volumes 0.30 m^3 and 0.50 m^3, by a fixed wall that is permeable to heat, as shown in the diagram below. The left and right compartments are filled with 2.0 mol and 3.0 mol of ideal gases, respectively.

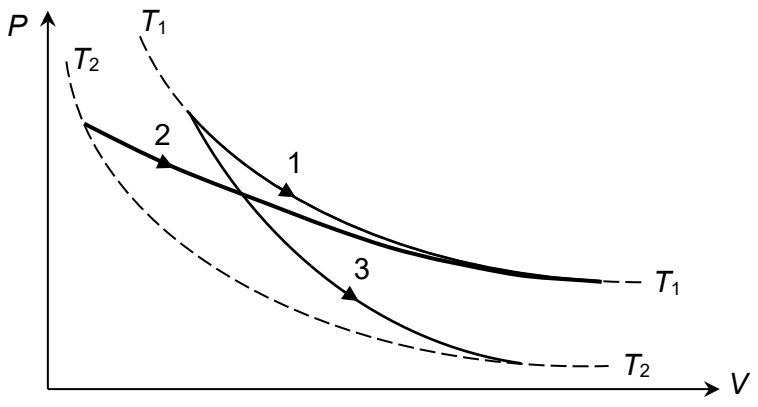
At equilibrium, what is the ratio of the pressure in the left compartment to that in the right compartment?



A 0.40 **B** 0.90 **C** 1.1 **D** 2.5

3 An ideal gas of fixed quantity can undergo the three different processes 1, 2 and 3 as shown in the figure below. The dotted lines are isotherms of temperatures T_1 and T_2.

Which process(es) can be adiabatic?



A 1, 2 and 3 **B** 2 and 3 **C** 2 only **D** 3 only

4 Which of the following statements is true?

A For a system of fixed mass, an increase in temperature is always accompanied by an increase in internal energy.

B For a system of fixed mass, an increase in internal energy is always accompanied by an increase in temperature.

C A system at a higher temperature must have more internal energy than another system at a lower temperature.

D A system with more internal energy must be at a higher temperature than another system with less internal energy.

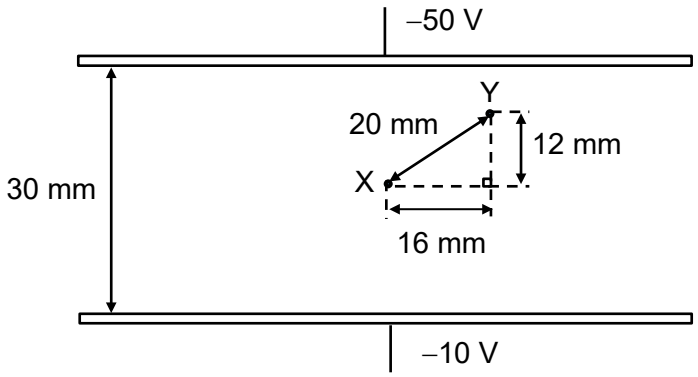
5 X and Y are two small identical conducting spheres with their centres separated by a distance *d*. X has a charge +6.0 μC and Y has a charge –2.0 μC. Both spheres experience an electric force of magnitude *F* towards each other.

The spheres are brought into contact and then separated to a distance $\frac{d}{2}$.

Which of the following correctly describes the electric force acting on each of the spheres after they are separated to a distance $\frac{d}{2}$?

	magnitude	**direction**
A	$\frac{2F}{3}$	attractive
B	$\frac{2F}{3}$	repulsive
C	$\frac{4F}{3}$	attractive
D	$\frac{4F}{3}$	repulsive

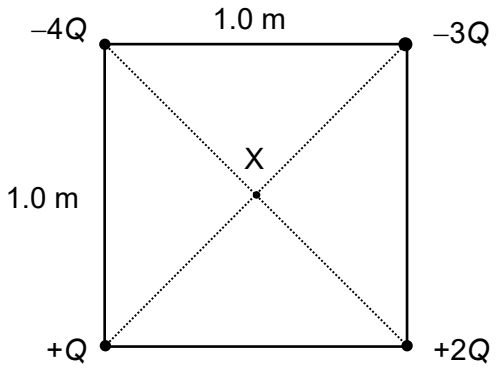
6 The diagram shows two large horizontal metal plates situated 30 mm apart. The top and bottom plates are at potentials −50 V and −10 V respectively. Point X is midway between the metal plates and point Y is a distance 20 mm from X as shown.



What is the work done by the electric force when a charge of −5.0 μC is moved from point X to point Y?

A -1.3×10^{-4} J **B** -8.0×10^{-5} J **C** 8.0×10^{-5} J **D** 1.3×10^{-4} J

7 The diagram shows four point charges of different magnitudes placed at the corners of a square of length 1.0 m. X lies at the geometrical centre of the square.



What is the resultant electric potential at X?

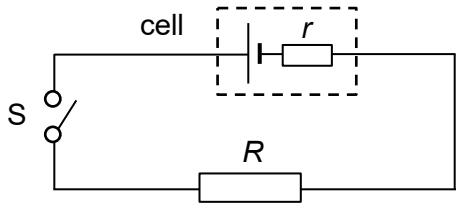
A $-7.2 \times 10^{10}\ Q$ **B** $-5.0 \times 10^{10}\ Q$ **C** $-2.5 \times 10^{10}\ Q$ **D** $1.3 \times 10^{11}\ Q$

8 A copper wire of diameter 2.1 mm carries a current of 20 A. The drift velocity of the electrons in the wire is 4.5×10^{-4} m s^{-1}.

What is the number of electrons per unit volume of the wire?

A 1.3×10^{10} m^{-3} **B** 1.3×10^{26} m^{-3} **C** 6.3×10^{28} m^{-3} **D** 8.0×10^{28} m^{-3}

9 A cell of internal resistance *r* is connected to a load of resistance *R*.



Which statement is correct when switch S is closed?

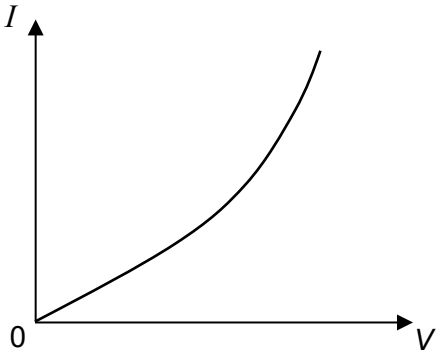
A The e.m.f. of the battery decreases because there is work done in driving charges through the internal resistance *r* of the battery.

B The e.m.f. of the battery decreases because there is work done in driving charges through the resistance *R*.

C The potential difference across the battery decreases because there is work done in driving charges through the internal resistance *r* of the battery.

D The potential difference across the battery decreases because there is work done in driving charges through the resistance *R*.

10 The graph shows the current-voltage (*I*-*V*) characteristics of a thermistor.



Which of the following statements explains the shape of the graph?

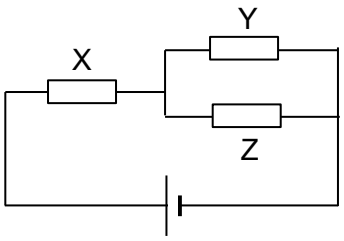
A As the temperature increases, the charge carriers collide with the atomic lattice more often and moves faster.

B As the temperature increases, there is a significant increase in the number of charge carriers.

C As the potential difference increases, the charge carriers experience a stronger electric field.

D As the potential difference increases, the charge carriers are able to move more easily through the atomic lattice.

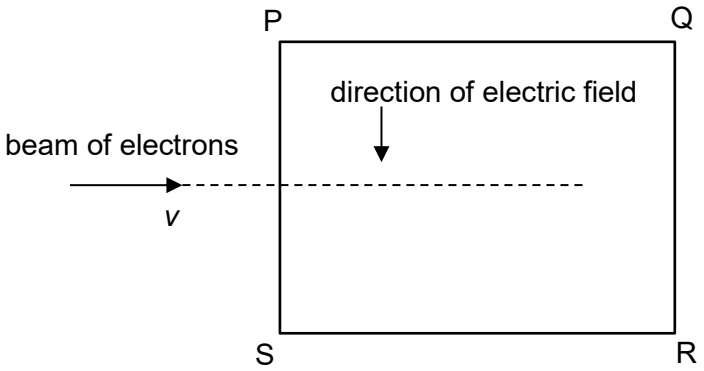
11 A battery of negligible internal resistance is connected to three identical resistors, X, Y and Z. The battery supplied a total power of 24 W.



What is the power dissipated in resistor Y?

A 4.0 W **B** 6.0 W **C** 8.0 W **D** 16 W

12 A beam of electrons is projected with speed *v* into a uniform electric field as shown. The electric field is applied vertically from PQ towards SR.



A uniform magnetic field is also applied in the same region and is adjusted until the electrons move through the region undeviated.

The magnitude of the magnetic field is now increased but its direction remains unchanged.

A beam of alpha particles (each of charge +2*e* and mass 6.6×10^{-27}) are now projected into the same region with speed *v*.

In which direction do the alpha particles travel?

A deviate towards PQ

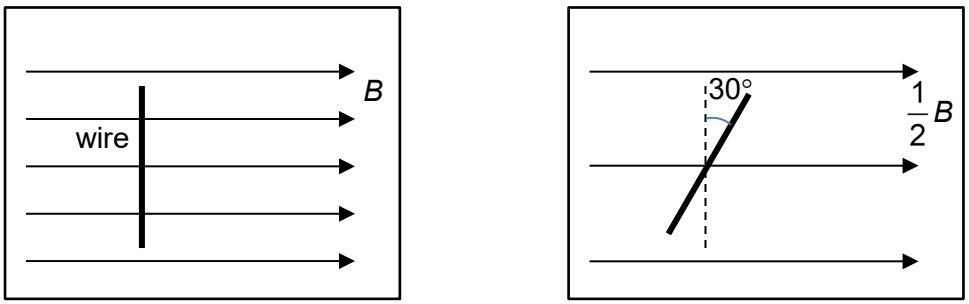
B deviate towards SR

C deviate out of the plane of the paper

D remains undeviated

13 The diagram shows a straight vertical current-carrying wire that lies perpendicular to a horizontal magnetic field of flux density *B*. A magnetic force of 8.0 mN acts on the wire.

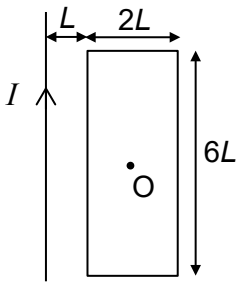
The wire is rotated through 30° and the magnetic flux density of the magnetic field is reduced to $\frac{1}{2}B$.



What is the magnetic force acting on the wire now?

A 2.0 mN **B** 3.5 mN **C** 6.9 mN **D** 8.0 mN

14 A rectangular wire frame of length 6*L* and width 2*L* is placed near a long, straight wire carrying a current I as shown. The distance between the left side of the wire frame and the long wire is *L*.



To induce an e.m.f. within the wire frame, each of the following changes is carried out separately:

1. Reduce the current in the long straight wire to zero in time *T*.
2. Shift the rectangular wire frame to the left by a distance *L* in time *T*.
3. Rotate the rectangular wire clockwise (from your view) about its centre O by 90 degrees in time *T*.

Which of the following lists the changes in *ascending* order of the magnitude of the average induced e.m.f.?

A 1, 2, 3 **B** 1, 3, 2 **C** 3, 1, 2 **D** 3, 2, 1

15 A coil of N turns and area A has a magnetic field of flux density B passing through it perpendicularly. When the magnetic field is reduced to zero at a constant rate, an e.m.f. V is induced in the coil.

What is the time taken for the magnetic field to become zero?

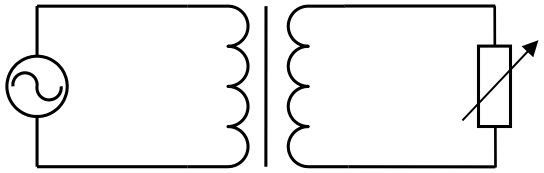
A $\frac{BA}{V}$ **B** $\frac{NB}{V}$ **C** $\frac{NBA}{V}$ **D** $NBAV$

16 An alternating voltage supply has a r.m.s. voltage of 120 V. When connected to this supply, a resistor dissipates energy at an average rate of 500 W. The resistor is then connected to a 240 V d.c. supply.

At what rate does the resistor now dissipate energy?

A 500 W **B** 1000 W **C** 2000 W **D** 4000 W

17 The primary coil of a transformer is connected to an alternating voltage supply. The secondary coil is connected across a variable resistor.



Which change will cause an increase in the potential difference across the secondary coil?

A Decrease the current in the primary coil.

B Decrease the number of turns of the primary coil.

C Decrease the cross-sectional area of the secondary coil.

D Decrease the resistance of the variable resistor.

18 An atom absorbs a photon of wavelength 350 nm and then re-emits the energy in the form of two photons to return to its original energy state.

If one of the emitted photons has a wavelength of 600 nm, what type of radiation is the other emitted photon?

A ultraviolet ray **B** violet light **C** red light **D** infrared

19 A particle of mass m has a de Broglie wavelength of λ when its kinetic energy is K.

In terms of K, what is the kinetic energy of another particle of mass $4m$ and de Broglie wavelength 2λ?

A $\frac{K}{16}$ **B** $\frac{K}{8}$ **C** K **D** $16K$

20 An electron is moving in a straight line at a velocity of 1.5×10^4 m s^{-1}.

If the uncertainty in the velocity is 0.50%, what is approximately the least uncertainty in the position of the electron?

A 4.9×10^{-8} m **B** 9.7×10^{-8} m **C** 9.7×10^{-7} m **D** 9.7×10^{-6} m