TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 MID-YEAR EXAMINATION

CANDIDATE NAME	( )
CIVICS GROUP	

H2 PHYSICS 9749

28 June 2024

30 minutes

Additional Materials: Multiple Choice Answer Sheet

Section A: Multiple Choice Question Booklet

READ THESE INSTRUCTIONS FIRST

You do not need to submit this Booklet at the end of the examination.

Write in soft pencil.
Do not use paper clips, glue or correction fluid.
Write your name, class and index number on the Multiple Choice Answer Sheet in the spaces provided.

There are **fifteen** questions on this paper. Answer **all** questions.
For each question there are four possible answers **A**, **B**, **C**, **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the Multiple Choice Answer Sheet.

Read the instructions on the Multiple Choice Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

You are to spend **30 minutes** on Section A.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi\times10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi))\times10^{-9}$ 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	=	$-\frac{GM}{r}$
temperature	T /K	=	T /°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	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{x_o^{\,2} - x^2}$
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	=	$x_o \sin \omega t$
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	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A: Multiple Choice Questions

1 The diagram shows gravitational equipotential lines of a region in space. The gravitational potential of each line is indicated in MJ kg^{-1}. A point mass *m* is placed as shown and is then released.

What is the direction of motion of the point mass and the change in its acceleration as it moves?

	direction of motion	acceleration
A	to the right	increasing
B	to the right	decreasing
C	to the left	increasing
D	to the left	decreasing

Q1 Ans: C

The gravitational potential becomes more negative towards the left. This means that the gravitational force is pointing towards the left. If an object is released at the point shown, it will move towards the left due to the gravitational force.

The spacing between the equipotentials is becoming closer towards the left. This means that the gravitational field strength is increasing towards the left. Since the acceleration due to gravity is equal to the gravitational field strength, the acceleration is increasing as the object moves further left.

2 When a beam of white light is shone onto a diffraction grating, only 3 orders of the entire visible spectrum (400 nm to 700 nm) are observed on the screen.

What is the number of lines per metre of the diffraction grating?

A 100 000 lines **B** 400 000 lines **C** 500 000 lines **D** 800 000 lines

Q2 Ans: B

$n = 3,\ d\sin\theta = n\lambda$

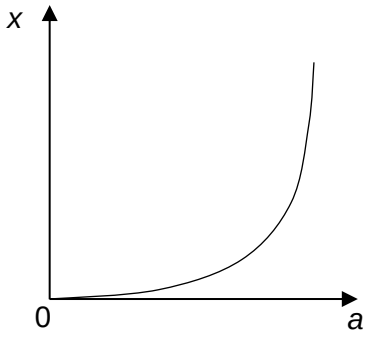
$d = \frac{1}{N}$, where N is number of lines per m

$\sin\theta < 1 \Rightarrow N < \frac{1}{n\lambda} = \frac{1}{(3)\left(700\times10^{-9}\right)} \approx 476190$

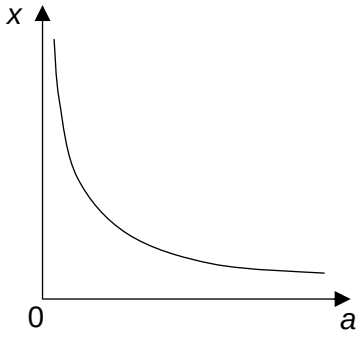
3 Interference fringes are produced by the Young's double slit experiment using monochromatic light.

Which one of the following graphs correctly shows the relationship between fringe spacing *x* and slit separation *a*?

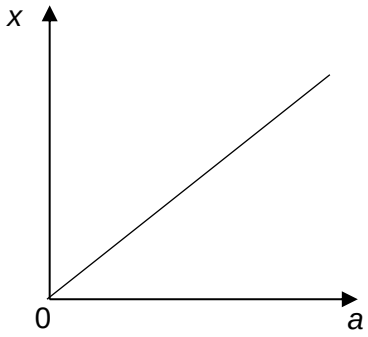
A



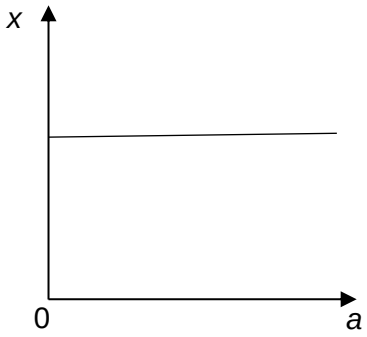
B



C



D



Q3 Ans: B

Since $x = \lambda D / a$

$x \propto 1/a$

4 A solid X is in thermal equilibrium with a solid Y, which is at the same temperature as a third solid Z. The three bodies are of different materials and masses.

Which one of the following statements is certainly correct?

A X and Y have the same heat capacity.

B Y and Z have the same internal energy.

C There is no net transfer of energy if X is placed in thermal contact with Z.

D It is not necessary that Y should be in thermal equilibrium with Z.

Q4 Ans: C

X is in thermal equilibrium with Y $\Rightarrow$ X and Y same temperature
Y and Z same temperature, so X, Y and Z are all same temperature
So there will be no net heat flow if X is placed in thermal contact with Z.

5 Two vessels X and Y, of volumes V_x and V_y are kept at temperatures T_x and T_y. They are filled with the same ideal gas and are connected by a narrow tube.

What is the ratio $\frac{\text{amount of gas in X}}{\text{amount of gas in Y}}$?

A $\frac{T_X V_X}{T_Y V_Y}$ **B** $\frac{T_X V_Y}{T_Y V_X}$ **C** $\frac{T_Y V_Y}{T_X V_X}$ **D** $\frac{T_Y V_X}{T_X V_Y}$

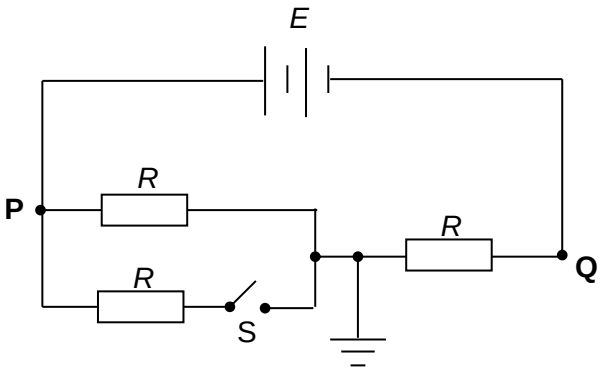
Q5 Ans: D

The gases are connected by a narrow tube $\Rightarrow$ they have the same pressure

$pV = nRT \Rightarrow n \propto \frac{V}{T}$

so $\frac{n_X}{n_Y} = \frac{\frac{V_X}{T_X}}{\frac{V_Y}{T_Y}} = \frac{T_Y V_X}{T_X V_Y}$

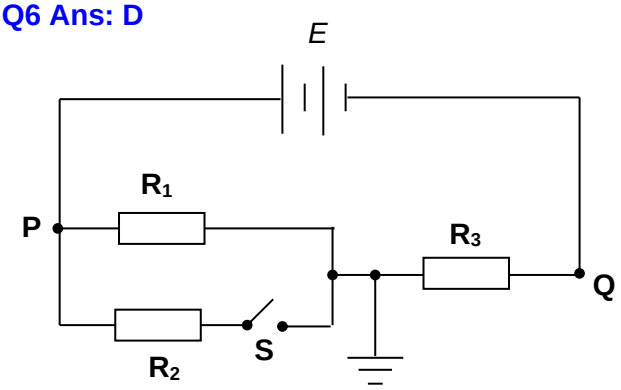
6 The circuit shows three resistors, each of resistance *R*, connected to a battery of constant electromotive force (e.m.f.) *E* with negligible internal resistance.



What happens to the electric potential at **P** and at **Q** when the switch S is closed?

	potential at **P**	potential at **Q**
A	unchanged	unchanged
B	increases	increases
C	increases	decreases
D	decreases	decreases

Q6 Ans: D

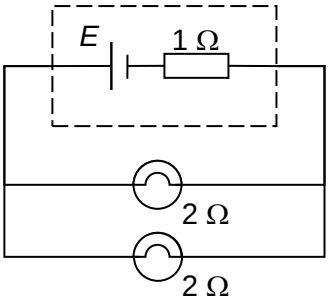


When switch **S** is closed, $\mathbf{R_1}$ and $\mathbf{R_2}$ become a parallel arrangement. Thus, p.d. across $\mathbf{R_1}$ and $\mathbf{R_2}$ decreases while p.d. across $\mathbf{R_3}$ increase since e.m.f. remains the same. As the potential at the earthed junction is zero, the potential at **P** becomes less positive, hence decrease while the potential at **Q** becomes more negative (hence, decrease).

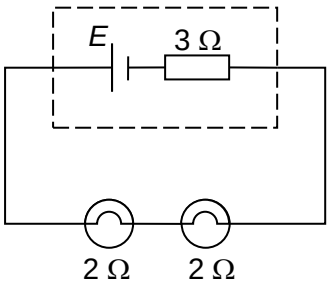
7 Batteries that have the same electromotive force (e.m.f.) E but different internal resistances are used to power two lamps, either connected in series or parallel.

Which circuit gives the highest brightness for each lamp?

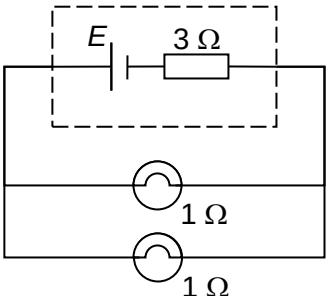
A



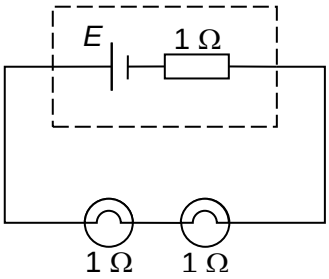
B



C



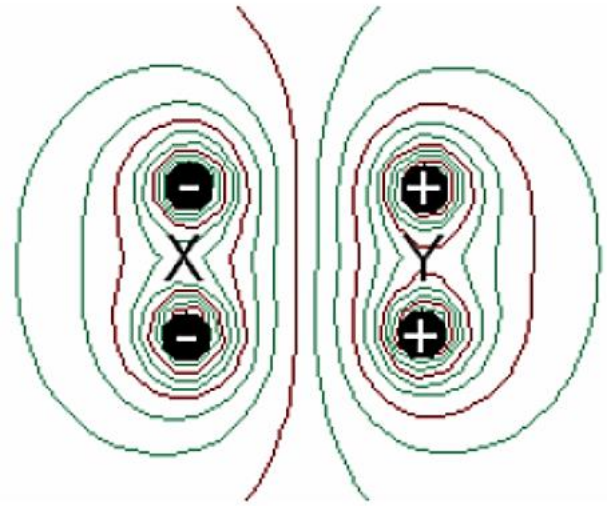
D



Q7 Ans: A

The potential difference across and power of each lamp are calculated:
Circuit A $V_{lamp} = 0.50\,E$, $P = V^2 / R = 0.13\,E^2$
Circuit B $V_{lamp} = 0.29\,E$, $P = V^2 / R = 0.041\,E^2$
Circuit C $V_{lamp} = 0.14\,E$, $P = V^2 / R = 0.020\,E^2$
Circuit D $V_{lamp} = 0.33\,E$, $P = V^2 / R = 0.11\,E^2$
Or use $P = I^2R$

8 The equipotential lines of four charges are shown below. Two of the charges are positive and the other two charges are negative.



An electron is moved from point X to point Y in a straight line.

Which of the following statements about the electron is correct?

A The electron's electric potential energy decreases.

B The electron's electric potential energy increases.

C The electron's electric potential energy falls and then increases.

D The electron's electric potential energy remains the same.

Q8 Ans: A

Potential at Y, V_y is positive (since the two charges near it are positive)
Potential at X, V_x is negative (since the two charges near it are negative)

Electron's electric potential energy, U

$$U = qV$$

$$\Delta U = q\Delta V$$

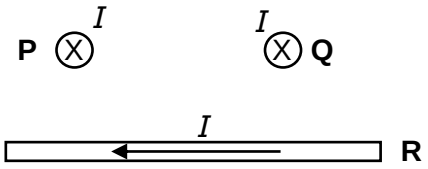
$$= qV_y - qV_x$$

$$= (-1.6 \times 10^{-19})[V_y - V_x]$$

$$=$$ negative [since V_y is positive, while V_x is negative]

Since the change is negative, the electric potential energy decreases.

9 Three long wires **P**, **Q** and **R** carrying same magnitude of current I are arranged as shown in the figure below. Currents in **P** and **Q** are flowing perpendicular into the plane of the paper while current in **R** is flowing to the left.



What is the direction of the resultant force acting on **P**?

A to the left

B to the right

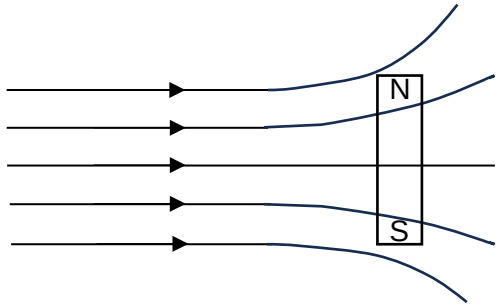
C downwards

D upwards

Q9 Ans: B

Magnetic field produced by Wire **R** does not affect Wire **P**. Since Wire **P** and Wire **Q** attract each other, the resultant force on Wire **P** is to the right.

10 A bar magnet is to be placed in a non-uniform magnetic field as shown.



Which of the following statements best describe the subsequent motion of the magnet?

A The magnet will undergo clockwise rotation and move to the left.

B The magnet will undergo clockwise rotation and move to the right.

C The magnet will undergo anticlockwise rotation and move to the left.

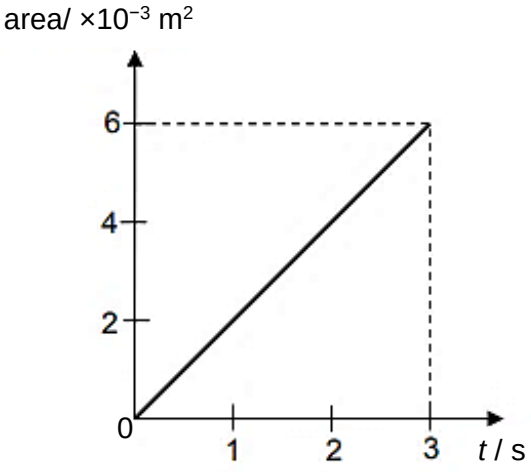
D The magnet will undergo anticlockwise rotation and move to the right.

Q10 Ans: A

The south pole of the magnet will be attracted to the north pole of the non-uniform magnetic field, causing it to rotate clockwise. The force of attraction on the south pole of the magnet is stronger and hence the magnet will move to the left.

11 A single circular loop of wire moves in a uniform magnetic field of flux density 1.2 T.

The graph shows how the area of the loop perpendicular to the magnetic field varies with time.



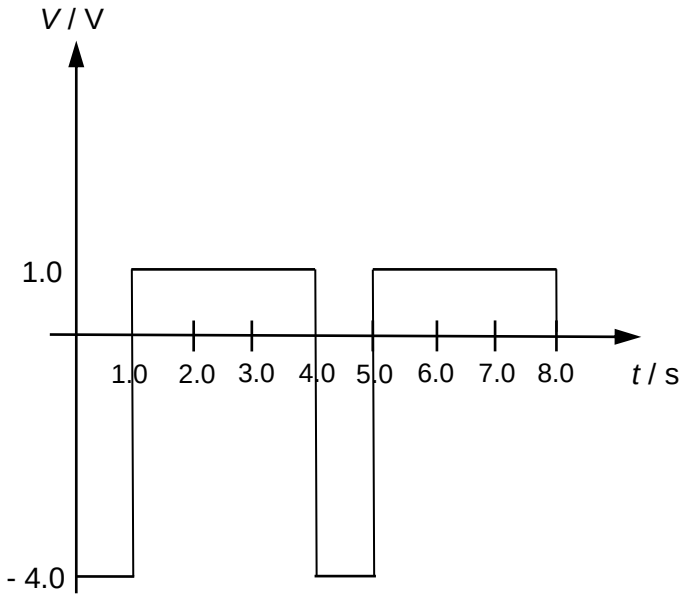
What is the e.m.f. induced?

A 1.2×10^{-3} V **B** 2.4×10^{-3} V **C** 3.6×10^{-3} V **D** 11×10^{-3} V

Q11 Ans: B

e.m.f. induced = d(*NBA*) / d*t*
N = 1, B is constant 1.2T,
e.m.f. induced = (1)(1.2) d*A*/d*t* = (1.2) (6 x 10^{-3} / 3) = 2.4×10^{-3} V

12 The graph shows the variation with time t of an alternating voltage V across a resistor of 2.0 Ω.



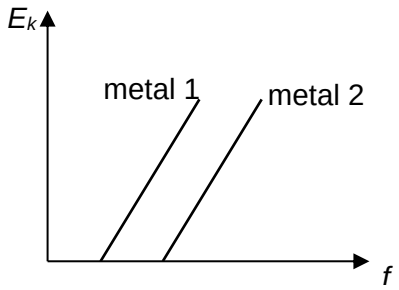
What is the r.m.s. current through the resistor?

A 1.1 A **B** 1.4 A **C** 2.0 A **D** 2.2 A

Q12 Ans: A

r.m.s. voltage = $\sqrt{([(4^2 \times 1) + (1^2 \times 3)]/4)} = 2.2$ V
r.m.s. current = 2.2 / 2.0 = 1.1 A

13 When monochromatic light of frequency f falls on a metal surface of work function Φ, photoelectrons may be emitted. The variation with f of the maximum kinetic energy E_k of these electrons for two metals are shown in the graph below.



Which of the following options correctly represent the work function, Φ and threshold frequency, F of each metal?

	work function, Φ	threshold frequency, F
A	$\Phi_1 > \Phi_2$	$F_1 > F_2$
B	$\Phi_1 > \Phi_2$	$F_1 < F_2$
C	$\Phi_1 < \Phi_2$	$F_1 > F_2$
D	$\Phi_1 < \Phi_2$	$F_1 < F_2$

Q13 Ans: D

$hf = \Phi + E_k$

$E_k = hf - \Phi$

x-intercept yields info on threshold frequency and y-intercept yields info on work function

14 Which of the following statements regarding X-ray spectra is incorrect?

A The wavelengths of the characteristic X-ray peaks are unique for each element.

B The continuous X-ray spectrum is formed when highly energetic electrons decelerate upon reaching the metal target and hence emitting X-ray photons of different wavelengths.

C Increasing the accelerating potential difference across an X-ray tube will increase the minimum wavelength of the X-ray spectrum.

D Using a heavier target metal with a higher atomic number will decrease the wavelength of the characteristic K-alpha X-ray peaks.

Q14 Ans: C

Since the electrons are accelerated by the electric field between the cathode and anode, increasing the accelerating potential would increase maximum kinetic energy of electrons. As such, minimum wavelength λ_{min} would decrease.

$$\frac{hc}{\lambda_{min}} = E_{k,\,\text{initial}} = e(\Delta V)$$

15 Which one of these nuclei contains an odd number of protons and an odd number of neutrons?

A $^{14}_{7}N$ **B** $^{13}_{6}C$ **C** $^{11}_{5}B$ **D** $^{17}_{9}F$

Q15 Ans: A

Number of protons for $^{14}_{7}N$ is 7 protons.

Number of neutrons for $^{14}_{7}N$ is 14 – 7 = 7 neutrons.

Thus A is the only nuclide in the list with an odd number of both protons and neutrons.

End of Section A