RAFFLES INSTITUTION
2019 Preliminary Examination

PHYSICS
Higher 2

Paper 1 Multiple Choice

9749/01

30 September 2019
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

There are **thirty** questions on this paper. Answer **all** 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 Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

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 appropriate scientific calculator is expected, where necessary.

This document consists of **14** printed pages.

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	=	$T / ^\circ\mathrm{C} + 273.15$
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	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 What is a reasonable estimate for the volume of a typical basketball?

A 70 cm^3 **B** 700 cm^3 **C** 7000 cm^3 **D** 70000 cm^3

2 An elevator is moving downwards with a constant downward acceleration of 3.5 m s^{-2}. A ball, held 2.0 m above the floor of the elevator and at rest with respect to the elevator, is released.

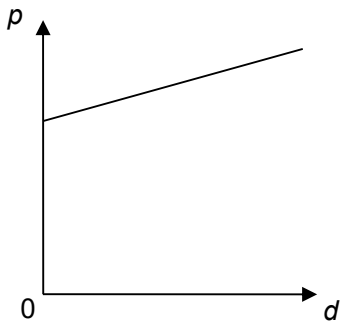
How long does it take for the ball to reach the floor of the elevator?

A 0.57 s **B** 0.64 s **C** 0.80 s **D** 1.1 s

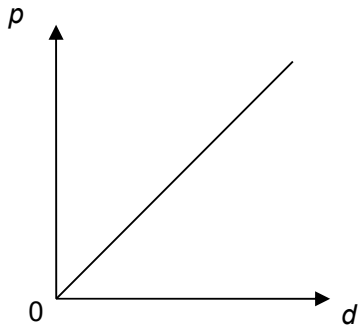
3 A particle is accelerated from rest by a constant force.

Which of the following graphs best represents the momentum *p* of the particle as a function of distance *d* travelled?

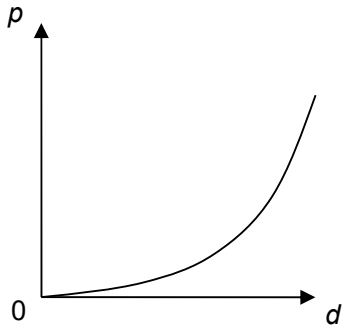
A



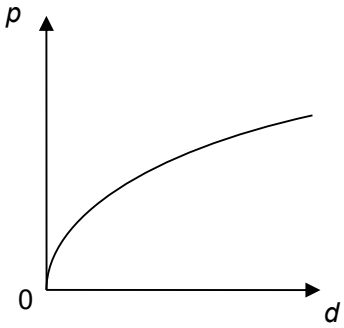
B



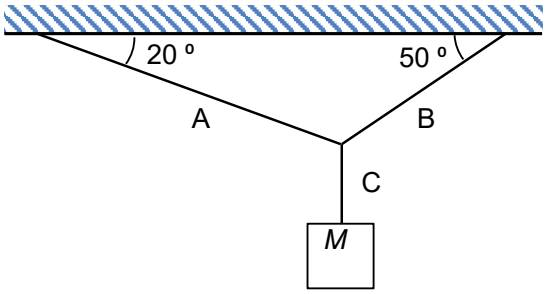
C



D



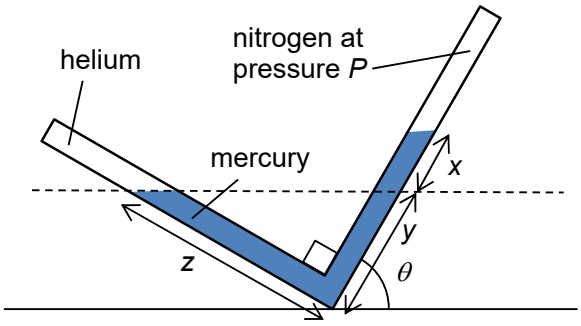
4 An object *M* of mass 5.0 kg is suspended from three cables A, B and C as shown below.



What is the tension in cable B?

A 32 N **B** 34 N **C** 49 N **D** 52 N

5 An L-shaped tube is sealed at both ends and tilted at angle θ as shown. One arm contains nitrogen gas at pressure *P* and the other arm contains helium gas. The gases are separated by mercury of density ρ with dimensions as shown.



What is the pressure of the helium gas?

A $z\rho g\cos\theta$

B $P + x\rho g$

C $P + x\rho g\sin\theta$

D $P - (x + y)\rho g\sin\theta$

6 An electric motor lifts a 350 kg mass through a vertical height of 110 m in 3.0 minutes at a constant speed. During the lifting process, a resistive force of 1000 N acts constantly on the mass.

What is the power delivered by the electrical motor?

A 1.5 kW **B** 2.1 kW **C** 2.7 kW **D** 11 kW

7 A mass is attached to the lower end of a vertical spring and supported such that the spring is unstretched. The mass is then released from rest. It oscillates and eventually comes to rest.

Which of the following correctly relates the changes in the energy of the spring-mass system which may occur during this process?

A	loss in gravitational potential energy	=	loss in elastic potential energy + gain in kinetic energy + energy dissipated as heat
B	gain in gravitational potential energy	=	gain in elastic potential energy + gain in kinetic energy + energy dissipated as heat
C	loss in gravitational potential energy + energy dissipated as heat	=	loss in elastic potential energy + gain in kinetic energy
D	loss in gravitational potential energy	=	gain in elastic potential energy + energy dissipated as heat

8 A Ferris wheel takes 30 minutes to complete one revolution. The diameter of the wheel is 150 m.

What is the linear speed of the wheel?

A 0.042 m s^{-1} **B** 0.26 m s^{-1} **C** 0.52 m s^{-1} **D** 16 m s^{-1}

9 An aircraft is performing a horizontal circular turn at a constant speed of 700 m s^{-1} with a turning radius of 85 km.

What is the ratio of the centripetal force to the weight of the aircraft?

A 0.00084 **B** 0.59 **C** 1.7 **D** 5.8

10 A satellite orbits the Earth at an altitude of 200 km. Assume that the radius of the Earth is 6400 km, the gravitational force on the satellite compared with that when it is at the Earth's surface is approximately

A less by 6% **B** less by 3% **C** more by 3% **D** more by 6%

11 Which of the following statements regarding the gravitational field strength and acceleration of free fall at the surface of the Earth is true?

A The gravitational field strength is constant over the surface of the Earth but the acceleration of free fall varies from one location to another.

B The acceleration of free fall is larger at the Equator than at the North and South Poles.

C The gravitational field strength at the Equator can be obtained by measuring the weight of a one-kilogram mass.

D The gravitational field strength is numerically greater than or equal to the acceleration of free fall.

12 Two vessels A and B of volume V and $8V$ respectively are connected by a tube of negligible volume and contain an ideal gas at an initial temperature of 10 °C.

Vessel A initially contains n moles of the ideal gas. Its temperature is then raised to 80 °C while the temperature of B is maintained at 10 °C.

How many moles of gas will be transferred between the vessels when steady state is reached?

A 0.18 n **B** 0.21 n **C** 0.82 n **D** 0.86 n

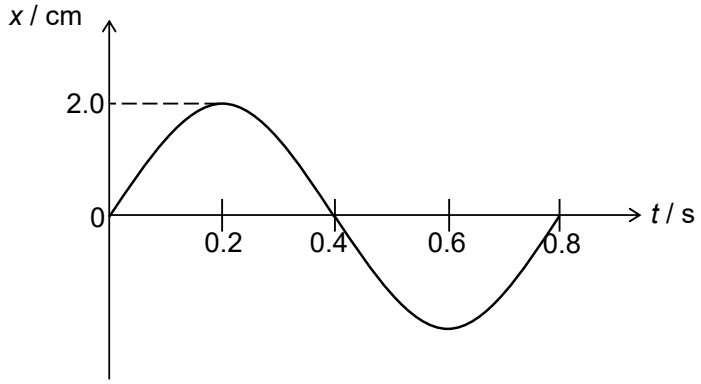
13 A well-lagged copper calorimeter of mass 57 g is filled with 250 g of paraffin. The calorimeter and paraffin are both initially at 25 °C.

What will be the increase in the temperature of the paraffin if a lead cube of mass 400 g and temperature 150 °C is placed in the paraffin?

heat capacity of copper calorimeter = 21.7 J K^{-1}
specific heat capacity of paraffin = 2130 J kg^{-1} K^{-1}
specific heat capacity of lead = 130 J kg^{-1} K^{-1}

A 8.93 °C **B** 9.21 °C **C** 10.7 °C **D** 12.9 °C

14 The variation with time of the displacement of a particle of mass 2.0 kg undergoing simple harmonic oscillations is shown below.



At t = 0.4 s,

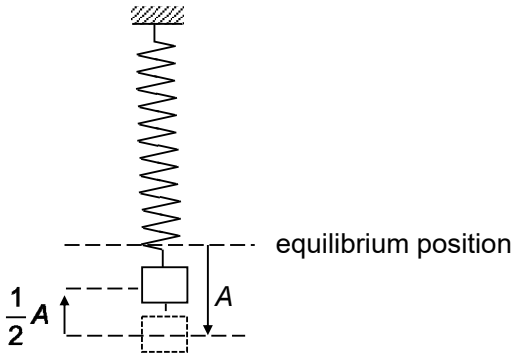
A the speed is 10 cm s^{-1} while the potential energy is 0 J.

B the speed is 16 cm s^{-1} while the potential energy is 0.025 J .

C the speed is 10 cm s^{-1} while the acceleration is 0 m s^{-2}.

D the speed is 16 cm s^{-1} while the acceleration is 0 m s^{-2}.

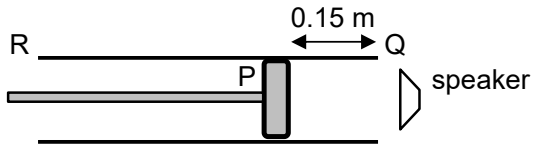
15 A mass suspended from a vertical spring is displaced vertically downwards by a distance A and released. It undergoes simple harmonic motion about the equilibrium position.



If the time taken for the mass to move through a distance of $\frac{1}{2}A$ from the point of release is τ, what is the period of the oscillation of the mass?

A 4τ **B** 6τ **C** 8τ **D** 12τ

16 A sound wave is generated by a speaker placed near the end Q of the tube QR. As the piston P is moved from end Q towards R, a loud sound is first heard when PQ is 0.15 m. The speed of sound is 330 m s^{-1}.



What is the frequency of the sound generated by the speaker?

A 200 Hz **B** 550 Hz **C** 1100 Hz **D** 2200 Hz

17 Which one of the following correctly compares characteristics of progressive and stationary waves on a string?

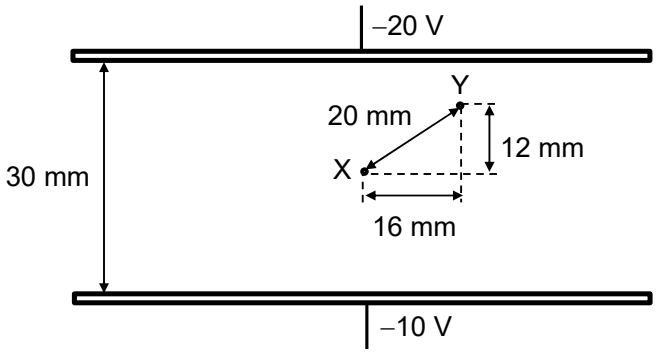
	progressive waves	stationary waves
A	Every point on the wave oscillates with the same amplitude	Amplitude of a point on the wave varies with position along the wave
B	Separation between two adjacent points of corresponding phase is one wavelength	Separation between a node and the adjacent antinode is half a wavelength
C	Adjacent points on the string oscillates in phase.	Adjacent points on the string oscillates out of phase.
D	Energy at any point changes from kinetic to potential and back again	Energy at the antinode is always kinetic

18 A beam of monochromatic light is incident normally on a diffraction grating. Second order diffracted beams are formed at angles of 15° to the normal.

What is the highest order of diffracted beam produced by this grating?

A 3 **B** 6 **C** 7 **D** 8

19 The diagram shows two large horizontal metal plates situated 30 mm apart. The top and bottom plates are at potentials −20 V and −10 V respectively.



What is the work done by the electric field when a charge of −5.0 μC is moved from point X midway between the metal plates to point Y?

A -3.3×10^{-5} J **B** -2.0×10^{-5} J **C** 2.0×10^{-5} J **D** 3.3×10^{-5} J

20 Which of the following statements is correct?

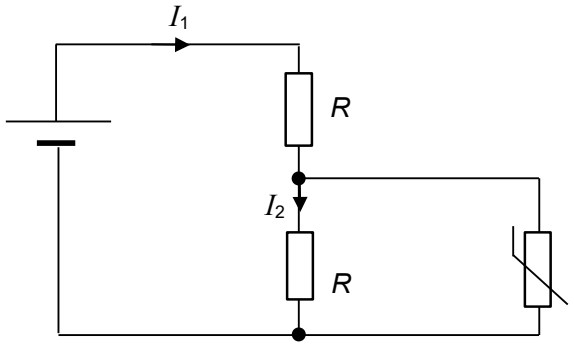
A The electric potential at a point must be zero if the electric field strength at that point is zero.

B The electric potential at a point must be non-zero if the electric field strength at that point is non-zero.

C The electric potential energy of a charged particle must decrease when it moves in the direction of an electric field.

D The electric potential must decrease in the direction of an electric field.

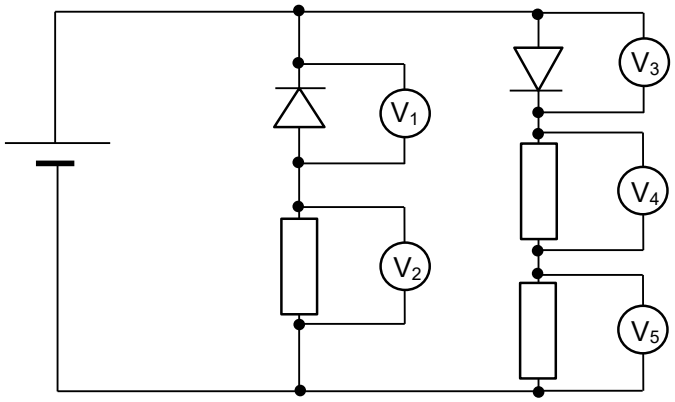
21 At room temperature, the resistance of a thermistor is *R*. It is connected to a circuit with two resistors, each of resistance *R*. The currents in the two resistors are I_1 and I_2 as shown.



How do the currents change when the temperature of the thermistor increases?

	I_1	I_2
A	increases	decreases
B	increases	increases
C	decreases	decreases
D	decreases	increases

22 A circuit consisting of a battery, two ideal diodes and three identical resistors is shown below. The potential difference across each component is measured using ideal voltmeters.



Which statement is correct?

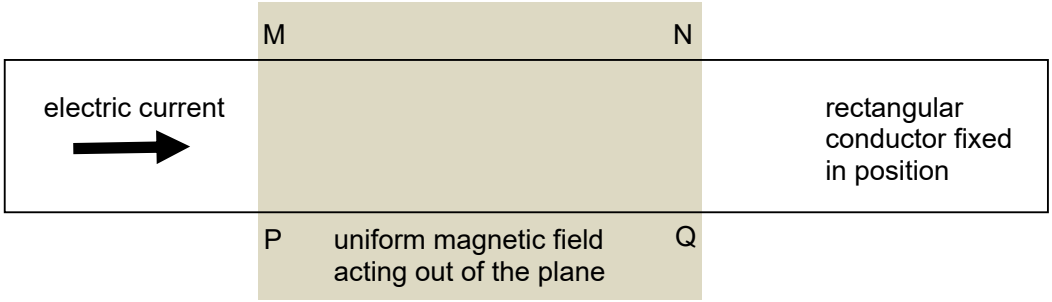
A The reading in V_1 is zero.

B The reading in V_2 is equal to the sum of the readings in V_4 and V_5.

C The readings in V_2 and V_3 are the same.

D The readings in V_3, V_4 and V_5 are the same.

23 MN and PQ are the upper and the lower sides of a rectangular conductor, respectively. An electric current is passed through the conductor, which is fixed in position, and placed in a uniform magnetic field pointing out of the plane of the paper as shown. This results in a potential difference between MN and PQ.

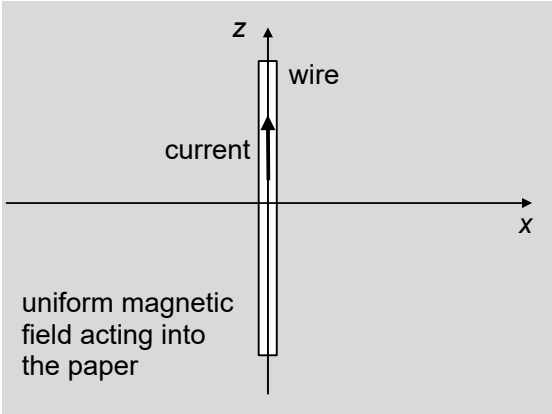


The current may be due to the flow of either positive or negative charge carriers.

Which side, MN or PQ, in each case, is at a higher potential?

	positive charge carriers	negative charge carriers
A	MN	MN
B	MN	PQ
C	PQ	MN
D	PQ	PQ

24 A wire carrying a current flowing in the positive z-direction is placed within a uniform magnetic field as shown. The magnetic field acts along the *y*-axis into the plane of the paper.



Which of the following independent changes leaves the magnitude of the magnetic force on the wire unchanged?

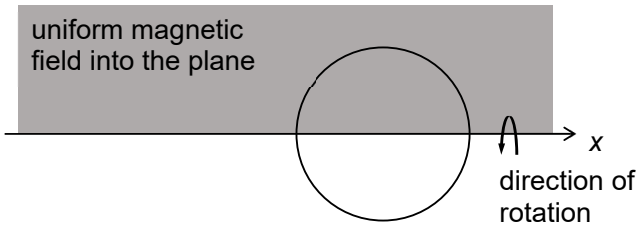
A Increase the current

B Increase the flux density

C Rotate the wire about the *x*-axis

D Rotate the wire about the *y*-axis

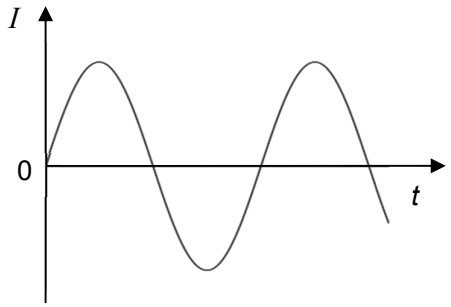
25 A coil of one turn is positioned in the plane of the paper such that the upper half of the coil is within a uniform magnetic field acting into the plane of the paper, as shown. The *x*-axis is along the edge of the magnetic field and passes through the centre of the coil.



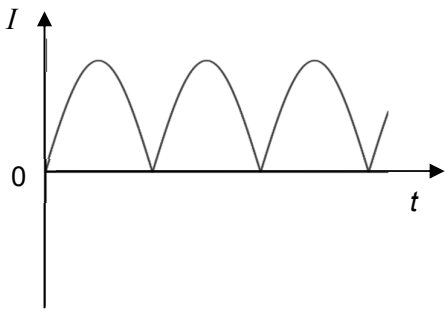
At time $t = 0$, the coil starts to rotate about the *x*-axis from the position shown.

Which of the following graphs correctly describes the variation of the induced current I in the coil with time t?

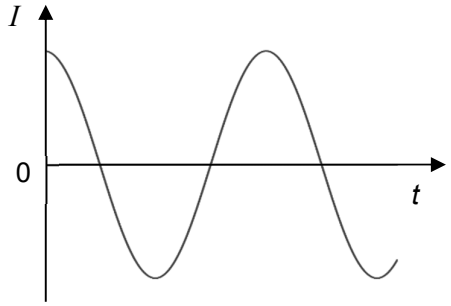
A



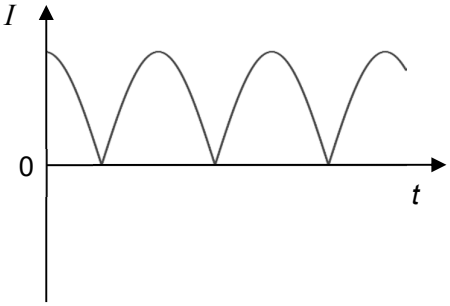
B



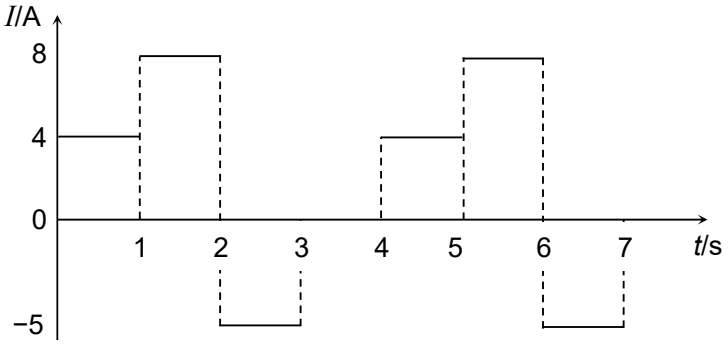
C



D



26 The diagram below shows the periodic variation of an electric current with time.



What is the value of the root-mean-square current?

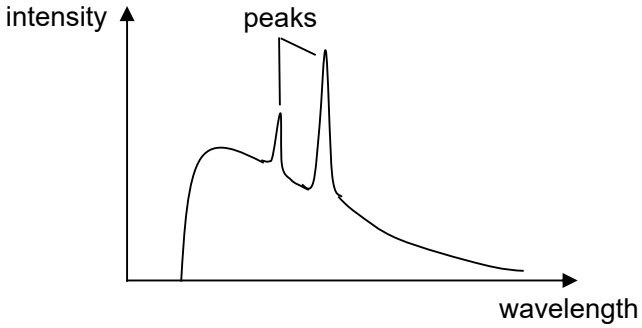
A 2.06 A **B** 5.12 A **C** 5.92 A **D** 26.3 A

27 A 1.00 kW radio transmitter operates at a frequency of 880 kHz.

How many photons per second does it emit?

A 8.80×10^{8} **B** 1.71×10^{30} **C** 4.24×10^{33} **D** 1.33×10^{42}

28 The following graph shows the spectrum of X-rays emitted from an X-ray tube.



If the potential difference between the target and cathode is increased, which one of the following combinations represents a possible change in wavelength and intensity of the peaks?

	Wavelength	Intensity
A	remain the same	increase
B	decrease	remain the same
C	remain the same	remain the same
D	decrease	increase

29 An induced nuclear fission reaction may be represented by the equation

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{98}_{40}\text{Zr} + {}^{136}_{52}\text{Te} + 2\,{}^{1}_{0}\text{n}$$

The binding energy per nucleon *E* for the nuclides involved in the reaction are as shown:

Nuclide	*E* / MeV
$^{235}_{92}\text{U}$	7.60
$^{98}_{40}\text{Zr}$	8.58
$^{136}_{52}\text{Te}$	8.32

What is the energy released in the reaction?

A 186 MeV **B** 196 MeV **C** 1970 MeV **D** 3760 MeV

30 The uranium nuclide $^{238}_{92}\text{U}$ undergoes a series of α and β decays to the stable lead nuclide $^{206}_{82}\text{Pb}$.

What is the number of α decays and β decays in the series of decays?

A 5 α decays and 12 β decays

B 6 α decays and 8 β decays

C 7 α decays and 4 β decays

D 8 α decays and 6 β decays