[3220/434] 1993

SCOTTISH CERTIFICATE OF EDUCATION

PHYSICS (REVISED)

Higher Grade—PAPER I

Wednesday, 19th May—9.30 a.m. to 11.00 a.m.

READ CAREFULLY

1. **All questions should be attempted.**
2. **The following data may be required.**

Speed of light in vacuum c	$3{\cdot}00 \times 10^{8}\,\mathrm{m\,s^{-1}}$	Planck's constant h	$6{\cdot}63 \times 10^{-34}\,\mathrm{J\,s}$
Charge on electron e	$-1{\cdot}60 \times 10^{-19}\,\mathrm{C}$	Mass of electron m_e	$9{\cdot}11 \times 10^{-31}\,\mathrm{kg}$
Acceleration due to gravity g	$9{\cdot}8\,\mathrm{m\,s^{-2}}$	Mass of proton m_p	$1{\cdot}67 \times 10^{-27}\,\mathrm{kg}$

SECTION A (questions 1 to 30)

3. **Check that the answer sheet is for Physics (Revised) Higher I (Section A).**
4. **Answer the questions numbered 1 to 30 on the answer sheet provided.**
5. **Fill in the details required on the answer sheet.**
6. **Rough working, if required, should be done only on this question paper, or on the first two pages of the answer book provided—NOT on the answer sheet.**
7. **For each of the questions 1 to 30 there is only ONE correct answer.**
8. **Instructions as to how to record your answers to questions 1–30 are given on page two.**

SECTION B (questions 31 to 37)

9. **Answer questions numbered 31 to 37 in the answer book provided.**
10. **Fill in the details on the front of the answer book.**
11. **Enter the question number clearly in the margin of the answer book beside each of your answers to questions 31 to 37.**
12. **Care should be taken NOT to give an unreasonable number of significant figures in the final answers to calculations.**

UCP 3220/434 6/3/19860

SECTION A

For questions 1 to 30 in this section of the paper, an answer is recorded on the answer sheet by indicating the choice A, B, C, D or E by a stroke made in ink in the appropriate box of the answer sheet — see the example below.

EXAMPLE

The energy unit measured by the electricity meter in your home is the

A ampere

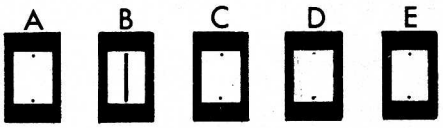
B kilowatt-hour

C watt

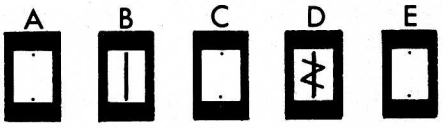
D coulomb

E volt.

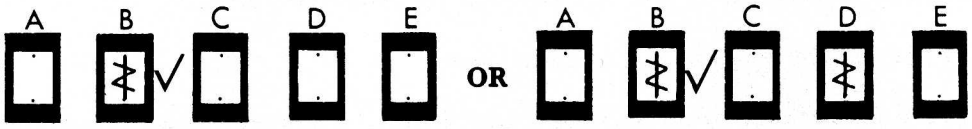
The correct answer to the question is B — kilowatt-hour. Record your answer by drawing a heavy vertical line joining the two dots in the appropriate box on your answer sheet in the column of boxes headed B. The entry on your answer sheet would now look like this:



If after you have recorded your answer you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer D to an answer B, your answer sheet would look like this:



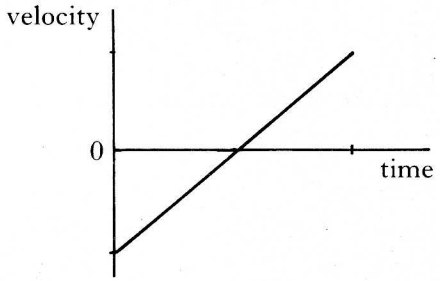
If you want to change back to an answer which has already been scored out, you should enter a tick (√) to the RIGHT of the box of your choice, thus:



SECTION A

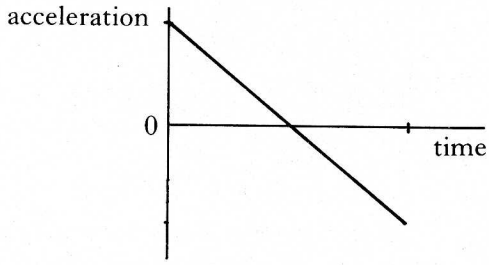
Answer questions 1–30 on the answer sheet.

1. The following velocity-time graph represents the motion of a trolley.

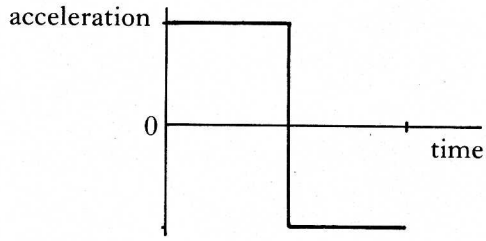


Which of the graphs below is the acceleration-time graph for the motion?

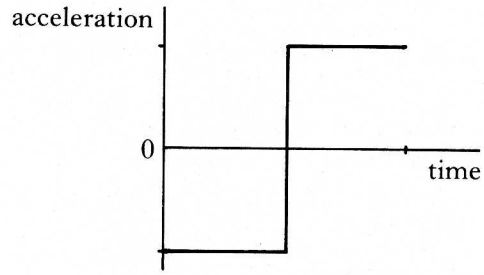
A



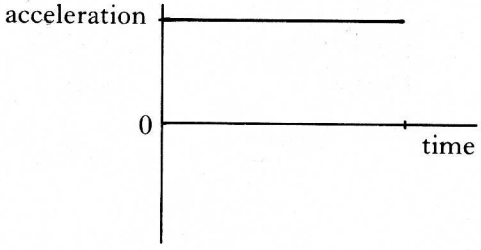
B



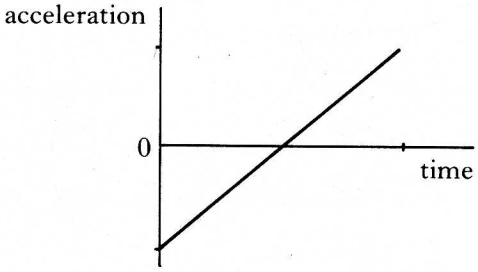
C



D



E



[Turn over

2. A car accelerates uniformly from rest and travels a distance of 60 m in 6·0 s. The acceleration of the car, in $m\,s^{-2}$, is

A 0·83

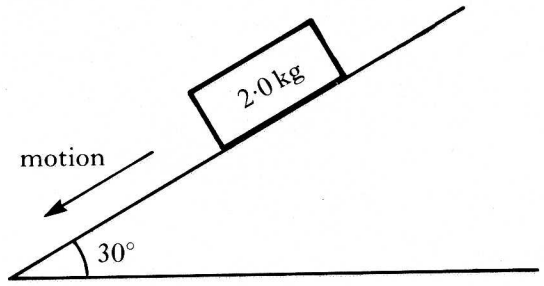
B 3·3

C 5·0

D 10

E 20.

3. A block of wood, of mass 2·0 kg, slides with a constant velocity down a slope. The slope makes an angle of 30° with the horizontal as shown in the diagram.



What is the value of the force of friction acting on the block?

A 1·0 N

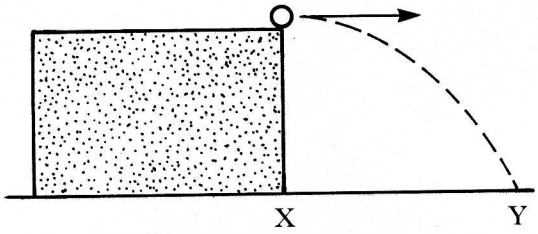
B 1·7 N

C 9·8 N

D 17·0 N

E 19·6 N

4. A ball is projected with a horizontal velocity from a bench. The ball travels a horizontal distance, XY, as shown.



Which of the following is/are used to calculate the distance XY?

I The mass of the ball

II The height of the table

III The horizontal velocity of the ball

A II only

B III only

C I and III only

D II and III only

E I, II and III

5. The unit of momentum is

A $kg\,m\,s^{-1}$

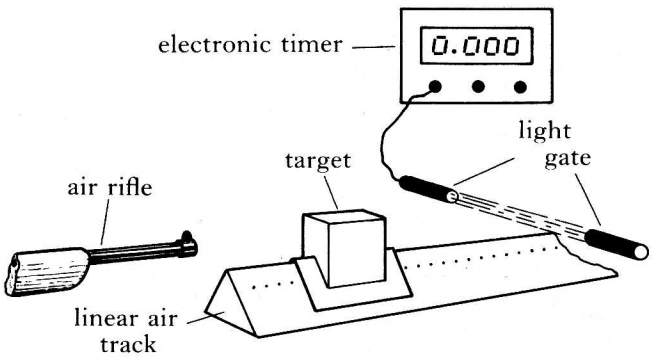
B N m

C $N\,m\,s^{-1}$

D $kg\,m\,s^{-2}$

E $N\,kg^{-1}$.

6. The experimental arrangement shown below is used to measure the speed of an air rifle pellet.



The speed of the pellet is calculated from the equation

$$\text{speed of pellet} = \frac{\text{final mass of target} \times \text{speed of target}}{\text{mass of pellet}}$$

The results from one experiment are

final mass of target = $(2{\cdot}00 \pm 0{\cdot}02)$ kg

mass of pellet = $(10{\cdot}0 \pm 0{\cdot}5)$ g

speed of target = $(0{\cdot}50 \pm 0{\cdot}01)\,\mathrm{m\,s^{-1}}$

Which of the following gives a good estimate of the percentage error in the calculated speed of the pellet?

A 1%

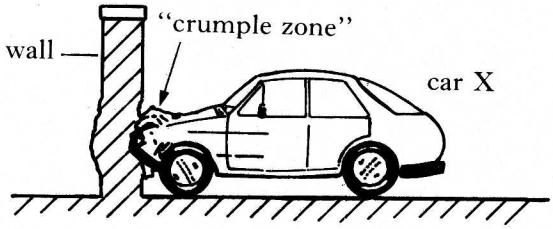
B 2%

C 3%

D 5%

E 8%

7. Car X is designed with a "crumple zone" so that the front of the car collapses during impact as shown in the diagram below.



A similar car, Y, of equal mass is built without a crumple zone. Both cars hit a wall at the same speed.

Comparing car X with car Y, which of the following statements is/are true during the collisions?

I The average force on car X is smaller.

II The time taken for car X to come to rest is greater.

III The change in momentum of car X is smaller.

A I only

B I and II only

C I and III only

D II and III only

E I, II and III

8. The pressure of a gas can be affected by factors such as its mass, its density, its volume and its temperature. Pressure is inversely proportional to volume if

A mass alone is constant

B density alone is constant

C temperature alone is constant

D mass and density are constant

E mass and temperature are constant.

9. A liquid is heated from 17 °C to 50 °C. The temperature **rise**, on the kelvin scale, is

A 33 K

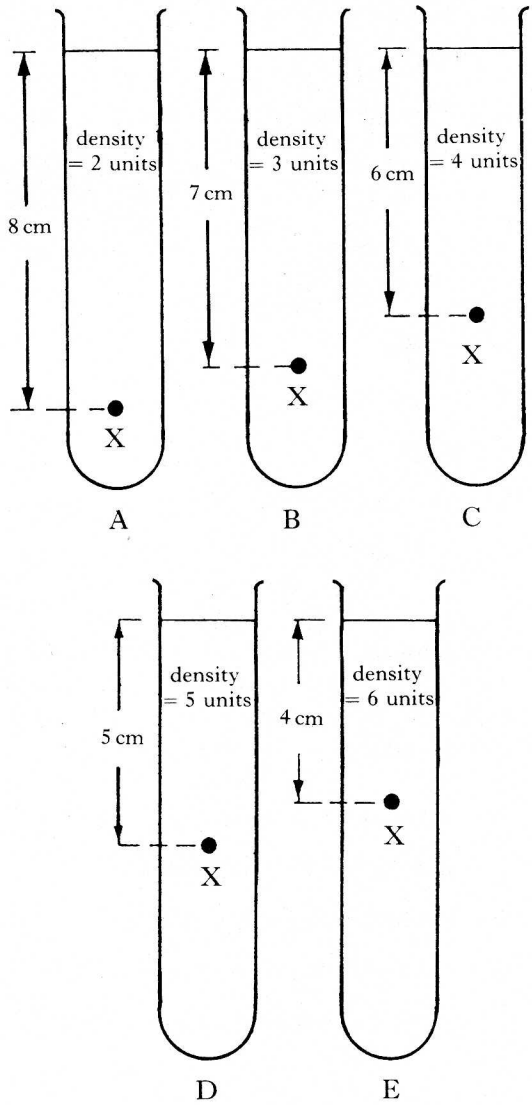
B 67 K

C 306 K

D 340 K

E 579 K.

10. Five liquids of different density are contained in separate, identical test tubes. The density of each liquid is given in the diagram. In which tube is the pressure greatest at point X?



11. A diver's air cylinder has a capacity of $0{\cdot}06\,m^3$. $4{\cdot}0\,m^3$ of air with a density of $1{\cdot}44\,kg\,m^{-3}$ is compressed into it. What is the density of the air in the cylinder?

A $0{\cdot}02\,kg\,m^{-3}$

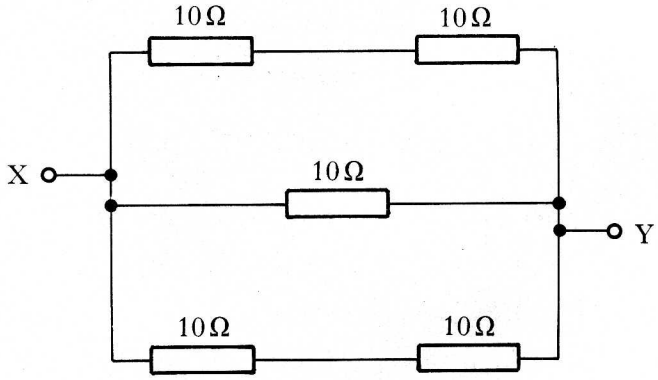
B $0{\cdot}17\,kg\,m^{-3}$

C $5{\cdot}76\,kg\,m^{-3}$

D $6{\cdot}00\,kg\,m^{-3}$

E $96{\cdot}0\,kg\,m^{-3}$

12. The diagram below shows part of an electrical circuit.



What is the resistance between X and Y?

A 0·2 Ω

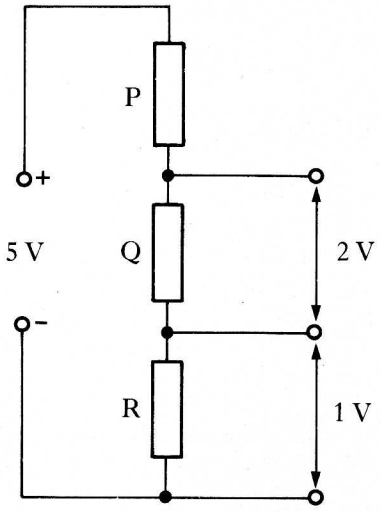
B 5 Ω

C 10 Ω

D 20 Ω

E 50 Ω

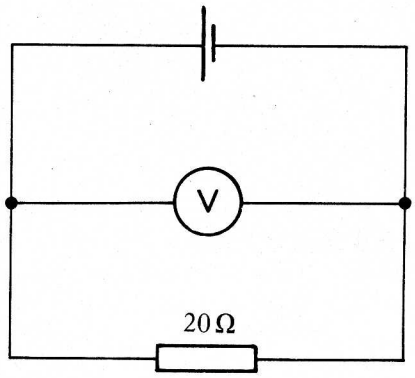
13. The circuit shown below is used to provide potential differences of 2 volts and 1 volt from a 5 volt supply with zero internal resistance.



Which of the following gives possible values, in kilohms, for resistors P, Q and R?

	P	Q	R
A	1	1	2
B	2	1	2
C	2	2	1
D	3	2	2
E	3	2	3

14. The reading on the high resistance voltmeter in the circuit shown below is 1·0 V.



The e.m.f. of the cell is 1·5 V.

The internal resistance of the cell is

A 0·1 Ω

B 0·5 Ω

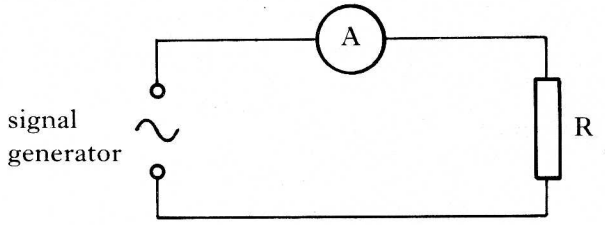
C 1·0 Ω

D 2·5 Ω

E 10 Ω.

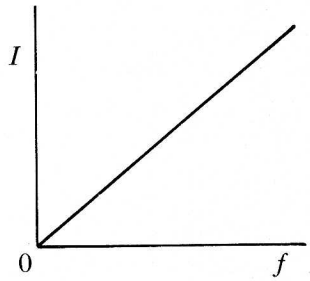
[Turn over

15. A resistor and an ammeter are connected to a signal generator having an output of constant amplitude and variable frequency.

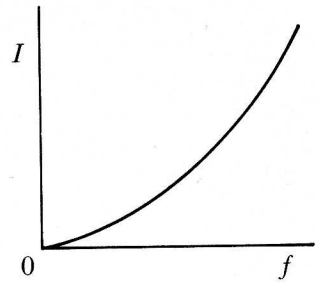


Which of the following graphs shows the correct relationship between the current I in the resistor and the output frequency f of the signal generator?

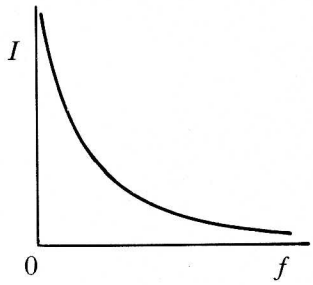
A



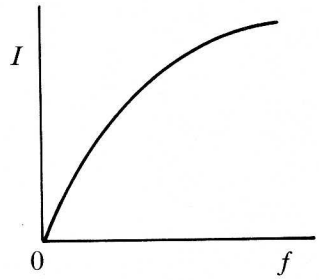
B



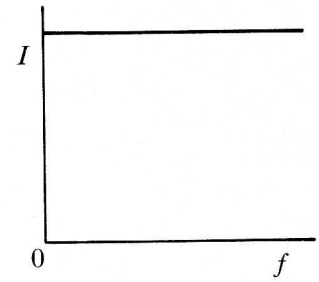
C



D



E



16. The energy stored in a capacitor, of capacitance C, when holding a charge Q is given by

A $\frac{1}{2}QC$

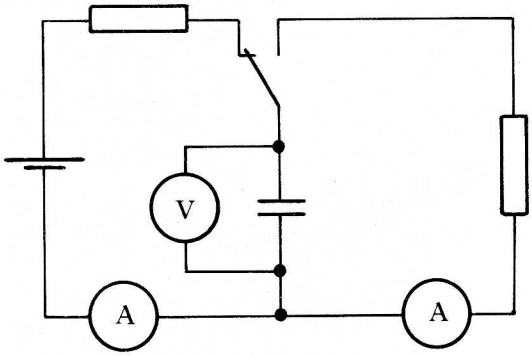
B $\frac{1}{2}\frac{Q}{C^2}$

C $\frac{1}{2}\frac{Q^2}{C}$

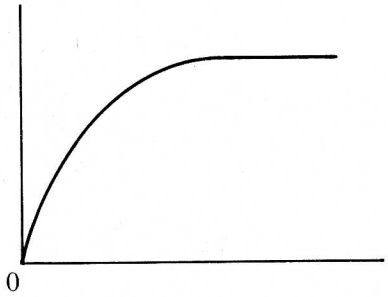
D $\frac{1}{2}QC^2$

E $\frac{1}{2}Q^2C$.

17. The circuit shown is used in an experiment to study the charging and discharging of a capacitor.



The unlabelled graph below is drawn using the results obtained during the experiment.



It is a graph of

A p.d. across the capacitor against time during charging

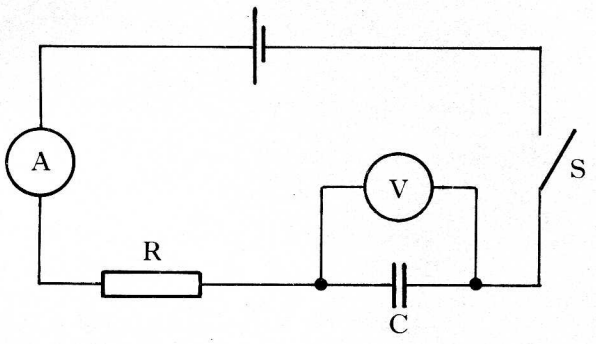
B current against time during charging

C current against p.d. across the capacitor during charging

D p.d. across the capacitor against time during discharging

E current against time during discharging.

18. In the following circuit, an uncharged capacitor, C, charges when switch S is closed.



This procedure is repeated with the resistor R replaced by one of **greater** resistance.

Which entry in the following table correctly shows the effect of this change on the initial charging current, the final p.d. across the capacitor and the final charge stored on the capacitor?

	Initial charging current	*Final p.d. across the capacitor*	*Final charge stored on the capacitor*
A	less	less	less
B	less	unchanged	unchanged
C	unchanged	less	less
D	unchanged	less	unchanged
E	unchanged	unchanged	unchanged

19. Which of the following statements is/are true for an ideal op-amp?

I It has infinite input resistance.

II Both input pins are at the same potential.

III The input current to the op-amp is zero.

A I only

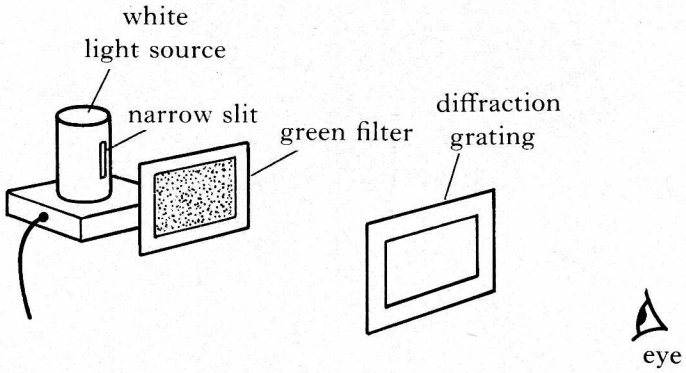
B II only

C I and II only

D II and III only

E I, II and III

20. A green filter is placed in front of a source of white light. The filtered light is viewed, as shown, through a diffraction grating with 100 lines per millimetre. A pattern of bright and dark bands is observed.



Which of the following changes would **decrease** the spacing between the bright bands?

I Use of a blue filter instead of the green filter

II Use of a grating with 50 lines per millimetre

III Use of a brighter lamp

A I only

B II only

C I and II only

D I and III only

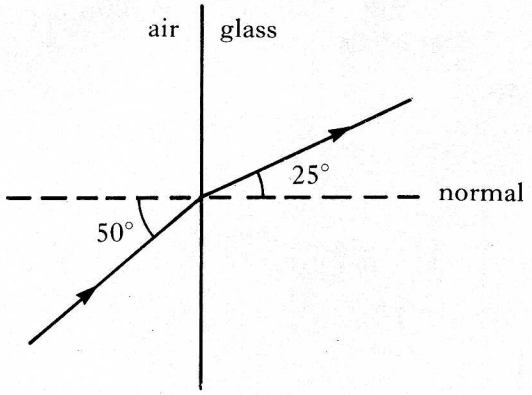
E II and III only

21. A ray of monochromatic light passes from air into perspex. What happens to the speed and frequency of the light on entering the perspex?

	Speed	*Frequency*
A	decreases	decreases
B	decreases	remains the same
C	remains the same	decreases
D	increases	remains the same
E	increases	increases

[Turn over

22. A ray of red light travels from air into glass as shown below.



The critical angle for the glass is

A 33·5°

B 41·1°

C 45·0°

D 45·2°

E 65·0°.

23. A space probe is positioned 3×10^{11} m from the Sun. It needs solar panels with an area of $4\,m^2$ to absorb sufficient energy from the Sun to keep it functioning correctly.

What area of solar panels would be needed to keep the probe functioning correctly if it is to be repositioned at a distance of 6×10^{11} m from the Sun?

A $1\,m^2$

B $2\,m^2$

C $4\,m^2$

D $8\,m^2$

E $16\,m^2$

24. Photons of energy $7{\cdot}0 \times 10^{-19}$ J are incident on a clean metal surface. The work function for the metal is $9{\cdot}0 \times 10^{-19}$ J.

Which one of the following is correct?

A No electrons are emitted from the metal.

B Electrons with a maximum kinetic energy of $2{\cdot}0 \times 10^{-19}$ J are emitted from the metal.

C Electrons with a maximum kinetic energy of $7{\cdot}0 \times 10^{-19}$ J are emitted from the metal.

D Electrons with a maximum kinetic energy of $9{\cdot}0 \times 10^{-19}$ J are emitted from the metal.

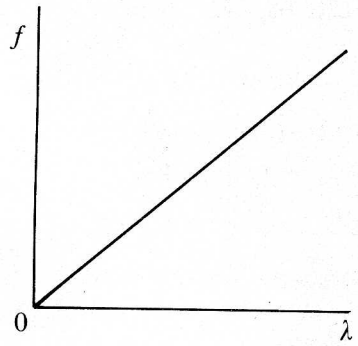
E Electrons with a maximum kinetic energy of $16{\cdot}0 \times 10^{-19}$ J are emitted from the metal.

25. Ultraviolet radiation is incident on a zinc plate. Photoelectrons with a certain maximum kinetic energy are released from the zinc. The intensity of the ultraviolet radiation is now increased. What happens to the maximum kinetic energy of the photoelectrons and the rate at which they are released?

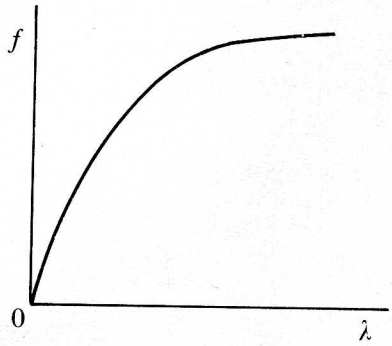
	Maximum kinetic energy of the photoelectrons	*Rate at which photoelectrons are released*
A	remains the same	increases
B	decreases	increases
C	increases	remains the same
D	increases	increases
E	remains the same	remains the same

26. Which of the following graphs correctly shows the relationship between the wavelength λ and the frequency f of photons of electromagnetic radiation?

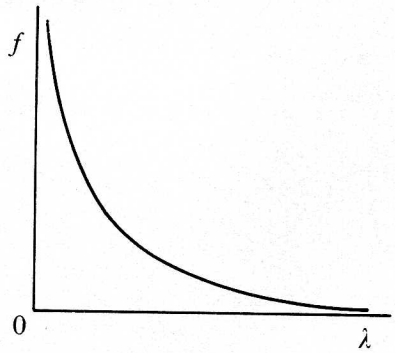
A



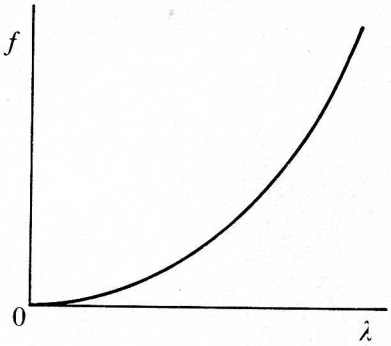
B



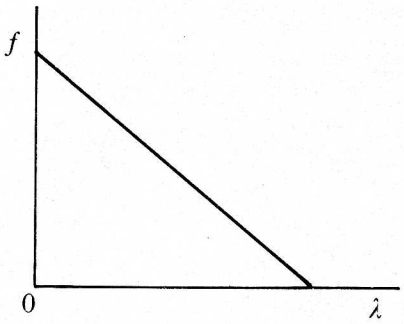
C



D

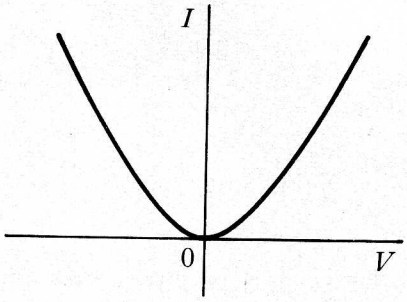


E

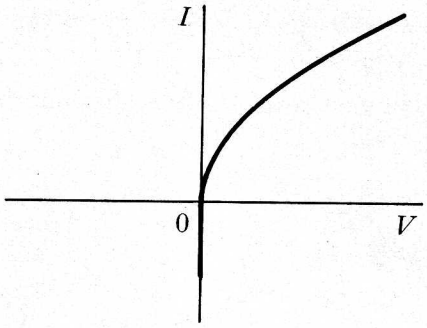


27. Which one of the following graphs shows the relationship between the current I in a p–n junction diode and the voltage V across the diode?

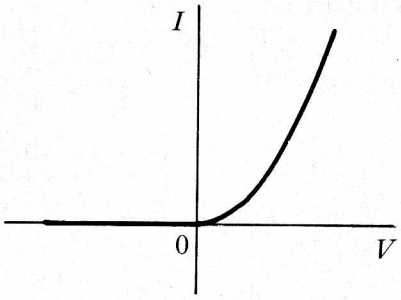
A



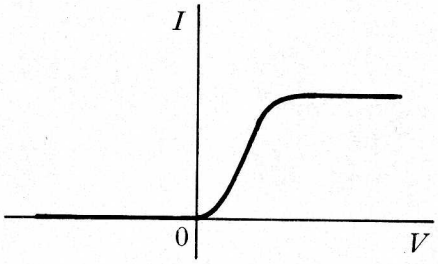
B



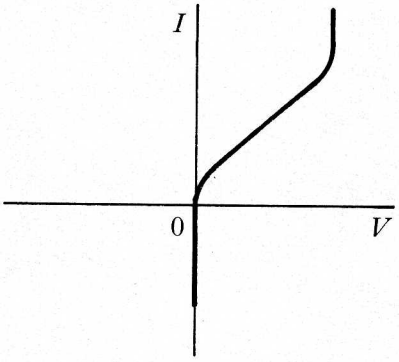
C



D



E



[Turn over

28. The typical dose equivalent rate, in millisieverts per year, due to background radiation is

A 0·002

B 0·02

C 0·2

D 2

E 20.

29. A radioactive isotope has a half-life of 20 minutes. A particular sample of this isotope gives a count rate of 3200 per second at 2 o'clock on a certain afternoon.

At what time on that day is the count rate 200 per second?

A 3.00 p.m.

B 3.20 p.m.

C 3.40 p.m.

D 4.40 p.m.

E 7.20 p.m.

30. The equation below represents a nuclear reaction.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{92}_{36}Kr + ^{141}_{56}Ba + ^{1}_{0}n + ^{1}_{0}n + ^{1}_{0}n$$

It is an example of

A nuclear fusion

B alpha particle emission

C beta particle emission

D induced nuclear fission

E spontaneous nuclear fission.

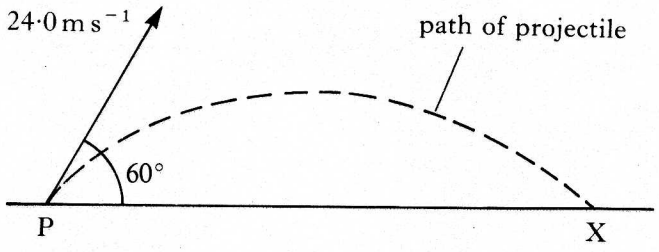
SECTION B

Write your answers to Questions 31 to 37 in the answer book.

Marks

31. During a visit to the Moon, an astronaut fires a small experimental projectile across a level surface. The projectile is launched, from point P, at a speed of $24{\cdot}0\,\mathrm{m\,s^{-1}}$ and at an angle of 60° to the horizontal.

The projectile lands 26·0 s later at point X.



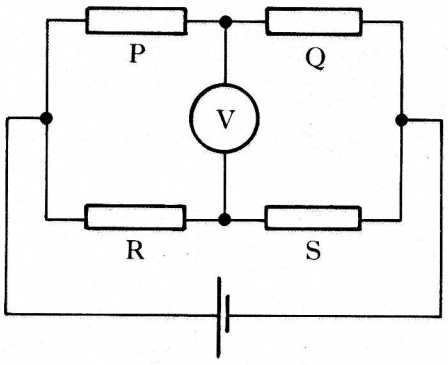
(*a*) Calculate the horizontal speed of the projectile at point P.

(*b*) Calculate the horizontal distance from P to X. **3**

32. The air pressure inside the passenger cabin of an airliner is 9×10^4 Pa when the airliner is at its cruising height. The pressure of the outside atmosphere at this height is 4×10^4 Pa.

Calculate the resultant force on the cabin door, of area $3\,\mathrm{m}^2$, caused by this difference in air pressure. **3**

33. The diagram below shows a **balanced** Wheatstone bridge circuit with four resistors P, Q, R and S.



(*a*) Explain what is meant by a **balanced** Wheatstone bridge.

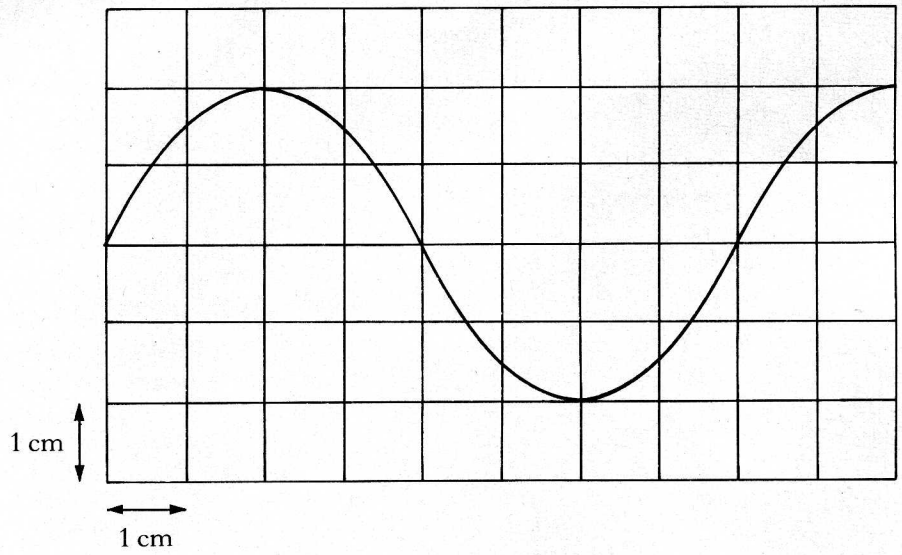
(*b*) After a period of use, the p.d. across the battery in the circuit decreases to half its original value.

What effect does this have on the reading on the voltmeter?

Justify your answer. **3**

[Turn over

34. An oscilloscope is connected across a resistor in a circuit. The trace obtained is shown below.



The peak voltage shown on the oscilloscope is 10 volts and the time base setting is $0{\cdot}2\,\text{ms cm}^{-1}$.

Calculate

(*a*) the r.m.s. voltage across the resistor

(*b*) the frequency of the a.c. voltage. **3**

35. A pupil wishes to measure the amount of energy stored in a $5\,\mu\text{F}$ capacitor which is charged to a p.d. of 10 V. He discharges the capacitor through a heating coil which is immersed in a small quantity of oil. The energy stored in the capacitor is calculated using the equation

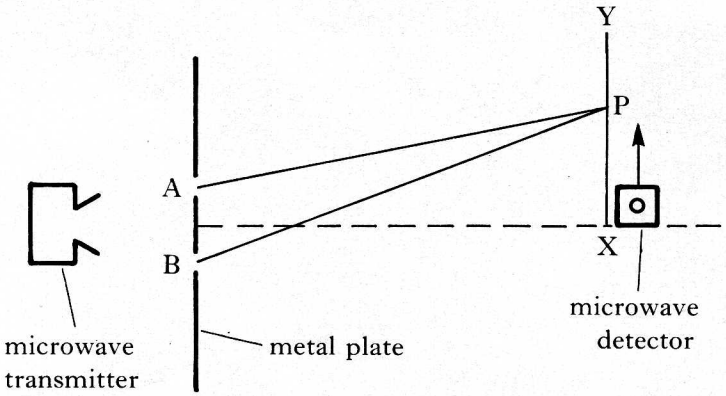
$$\text{energy stored in capacitor} = \text{specific heat capacity of oil} \times \text{mass of oil} \times \text{rise in temperature of oil}\,.$$

(*a*) State the assumption made by the pupil in using this equation.

(*b*) By considering the energy stored in the capacitor, explain why the measurement of the rise in the temperature of the oil is likely to be extremely inaccurate. **3**

Marks

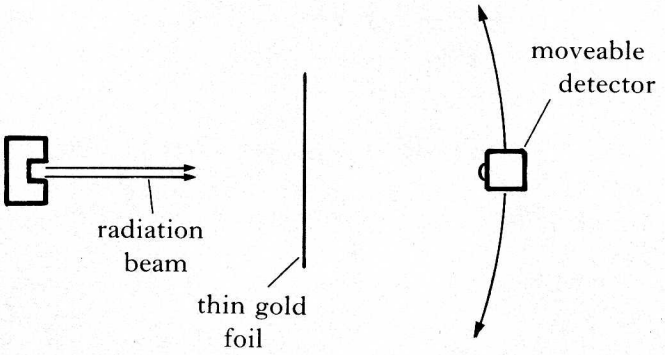
36. Microwaves are passed through two slits, A and B, in a metal plate as shown in the diagram below.



A microwave detector is moved along a straight line from X to Y. The **first minimum** of microwave intensity is detected at point P. The distance AP is 41 cm and BP is 43 cm.

Find the wavelength of the microwaves. **2**

37. In a famous experiment to investigate the structure of the atom, a beam of radiation is directed at a thin, gold foil target as shown in the diagram below.



The experiment shows that most of the radiation passes through the gold foil but some "bounces back" without passing through the foil.

(*a*) State the type of radiation used.

(*b*) Explain how the results of the experiment suggest that the mass of the atom is concentrated at its centre (nucleus). **3**

[*END OF QUESTION PAPER*]