SCOTTISH CERTIFICATE OF EDUCATION

PHYSICS (REVISED)

Higher Grade—PAPER I

Thursday, 14th May—9.30 a.m. to 11.00 a.m.

READ CAREFULLY

1. All questions should be attempted.
2. Use the approximation $g = 10\,\text{m}\,\text{s}^{-2}$ or $g = 10\,\text{N}\,\text{kg}^{-1}$.
   Any other data required will be found in the Science Data Booklet (1982 edition) provided.

SECTION A (questions 1–30)

3. Answer these questions on the answer sheet provided.
4. Check that the answer sheet is for Physics (Revised) Higher I (Section A).
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 question there is only ONE correct answer.
8. In this Section answer by indicating the choice A, B, C, D or E by a stroke made in INK in the appropriate place in the answer sheet—
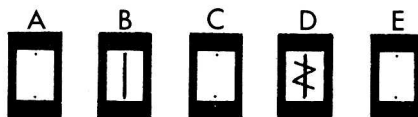
SAMPLE QUESTION FOR QUESTIONS 1–30

The momentum of a body is the product of

A   mass and velocity squared

B   mass and velocity

C   mass and acceleration

D   force and velocity

E   force and displacement.

The correct answer is B—mass and velocity. A **heavy** vertical line should be drawn joining the two dots in the appropriate box in the column headed B as shown in the example below.

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:
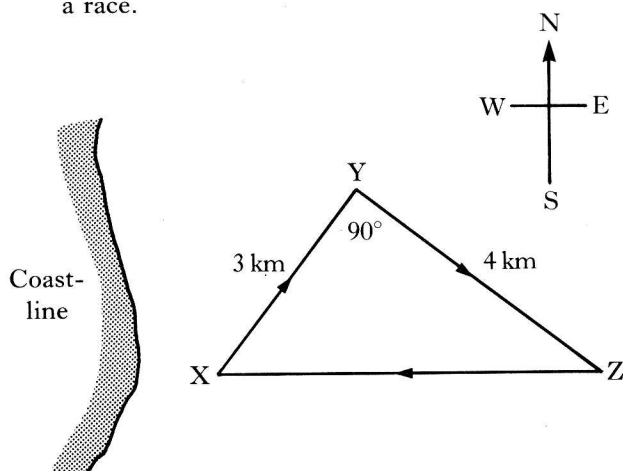

SECTION B (questions 31–37)

9. Answer these questions 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 beside each answer.
12. Care should be taken not to give an unreasonable number of significant figures in the final answers to calculations.
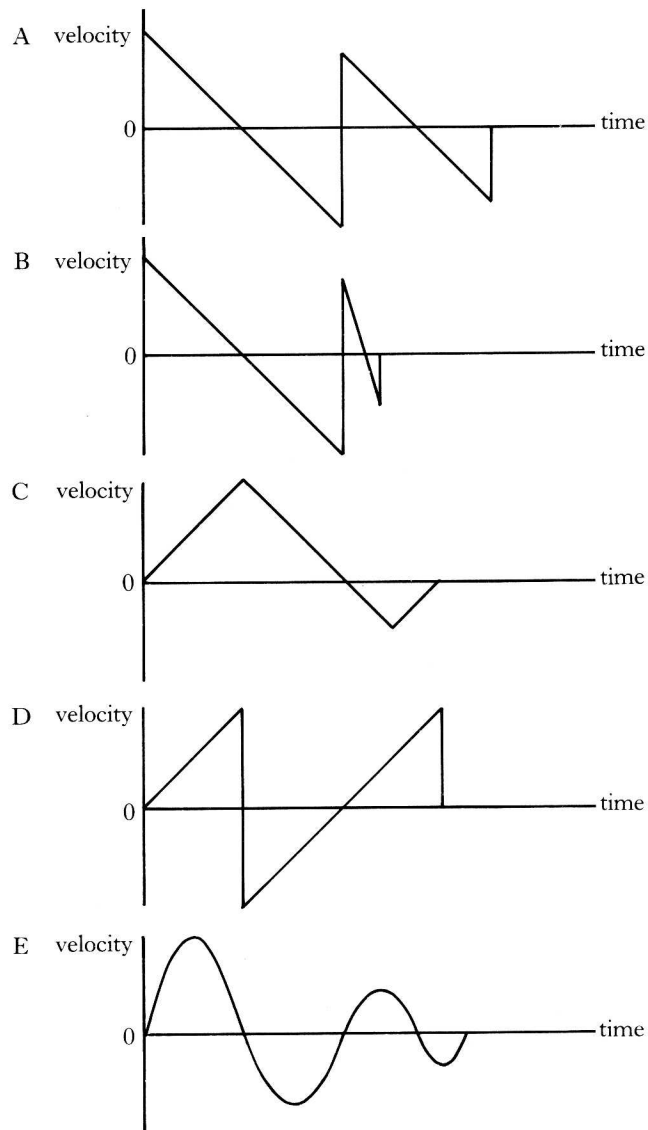
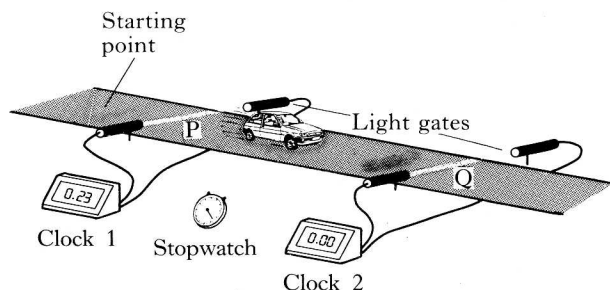1. A yacht follows the course shown below during a race.

The race starts and finishes at X. Which entry in the table below gives the displacement of the yacht at position Z relative to the start; and the distance covered up to position Z?

	Displacement	Distance
A	5 km due East	5 km
B	7 km due East	5 km due East
C	5 km	7 km due East
D	7 km due East	7 km
E	5 km due East	7 km

2. A ball is thrown vertically upwards from ground level. When it falls to the ground, it bounces several times before coming to rest. Which one of the following velocity–time graphs represents the motion of the ball from the instant it leaves the thrower's hand until it hits the ground for a second time?

3. A student sets up the apparatus in the diagram to measure the average acceleration of a model car as it travels between P and Q.

For one run, the following measurements were recorded along with their estimated errors:

clock 1 reading $= 0.23\,\text{s} \pm 0.01\,\text{s}$

clock 2 reading $= 0.12\,\text{s} \pm 0.01\,\text{s}$

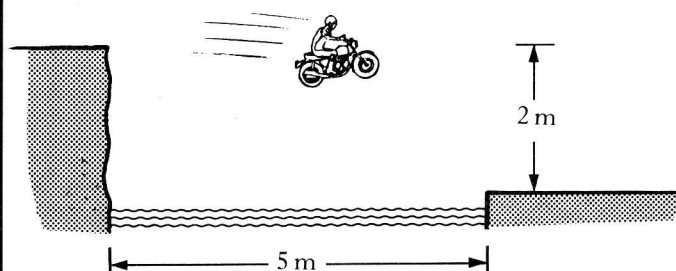stopwatch reading $= 0.95\,\text{s} \pm 0.20\,\text{s}$

length of car $= 0.050\,\text{m} \pm 0.002\,\text{m}$

distance PQ $= 0.30\,\text{m} \pm 0.01\,\text{m}$

The measurement which gives the largest percentage error is the

A   reading on clock 1

B   reading on clock 2

C   reading on the stopwatch
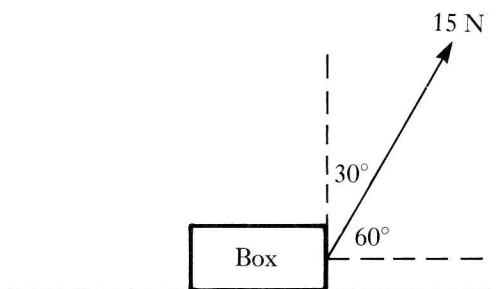
D   length of car

E   distance PQ.

4. A stunt motorcyclist attempts to jump a river which is 5 m wide. The bank from which he will take off is 2 m higher than the bank on which he will land as shown below.

What is the minimum horizontal speed he must achieve just before take-off to avoid landing in the river?

A $2{\cdot}0\,\text{m}\,\text{s}^{-1}$

B $3{\cdot}2\,\text{m}\,\text{s}^{-1}$

C $7{\cdot}9\,\text{m}\,\text{s}^{-1}$

D $10{\cdot}0\,\text{m}\,\text{s}^{-1}$

E $12{\cdot}5\,\text{m}\,\text{s}^{-1}$

5. A force of 15 N acts on a box as shown below.

Which entry in the following table correctly shows the horizontal and vertical components of the force?
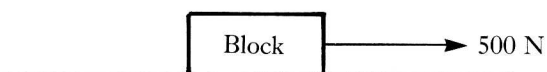
	Horizontal component/N	Vertical component/N
A	15 sin 60°	15 sin 30°
B	15 cos 60°	15 sin 30°
C	15 sin 60°	15 cos 60°
D	15 cos 30°	15 sin 30°
E	15 cos 60°	15 sin 60°

6. A hot air balloon of mass 300 kg has people with a total mass of 250 kg on board. It floats at a steady height.

The upthrust on the balloon is

A   0 N

B   500 N

C   2500 N

D   3000 N

E   5500 N.

7. A block of weight 1500 N is dragged along a horizontal road at constant speed by a force of 500 N.

What is the force of friction between the block and the road?

A   3 N
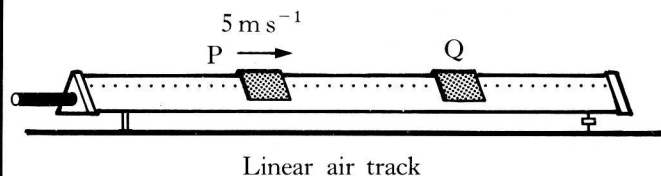
B   500 N

C   1000 N

D   1500 N

E   2000 N

8. Two identical metal spheres X and Y are dropped onto a horizontal surface. The distance Y falls is double the distance X falls.

Which of the following is/are true if the effects of air resistance are negligible?

  I   Y takes twice as long to fall as X.

 II   The maximum speed of Y is double the maximum speed of X.

III   The maximum kinetic energy of Y is double that of X.

A   I only

B   II only

C   III only

D   I and II only

E   I, II and III

9. The diagram below shows two vehicles, both of mass 0·2 kg, on a linear air track. Vehicle P is moving at 5 m s^{-1} towards vehicle Q, which is at rest before the collision.

Linear air track

After colliding, they move off **separately** to the right. Vehicle P moves with a speed of 2 m s^{-1} and vehicle Q moves with a speed of 3 m s^{-1}.

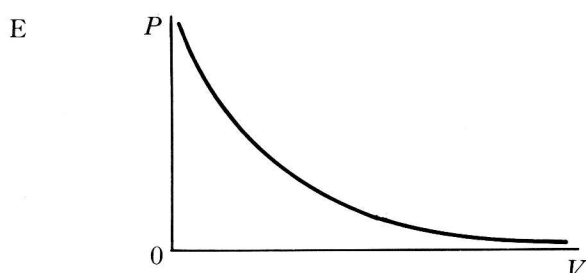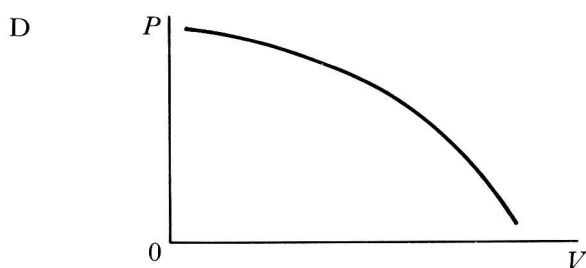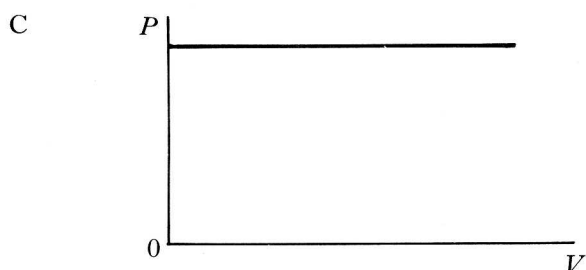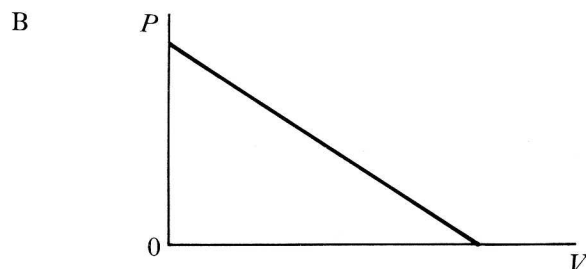Which one of the following correctly describes this collision?

	Momentum	Kinetic Energy	Type of Collision
A	lost	conserved	elastic
B	conserved	lost	elastic
C	conserved	conserved	elastic
D	lost	conserved	inelastic
E	conserved	lost	inelastic

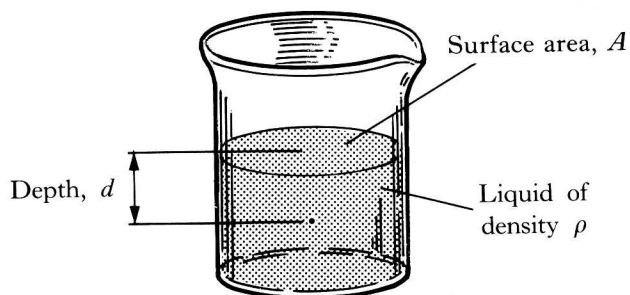**10.** A rectangular block of wood of mass 200 kg has dimensions of 2 m by 1 m by 0·1 m.

The **greatest** pressure the block can exert when lying on a level surface is

A 1×10^2 Pa

B 1×10^3 Pa

C 2×10^3 Pa

D 1×10^4 Pa

E 2×10^4 Pa.

11. Which one of the following graphs illustrates the correct relationship between the pressure P and volume V of a fixed mass of gas at constant temperature?

A

B

C

D

E

12. The glass beaker shown below contains a liquid of density ρ and surface area A.
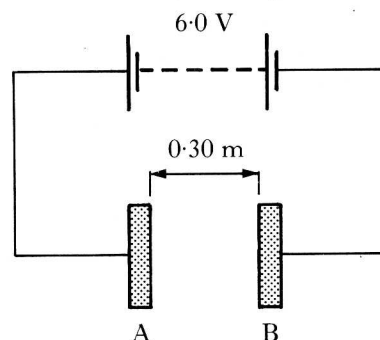

Surface area, A

Depth, d

Liquid of density ρ

Which of the following is/are true about the pressure, caused by the liquid, at depth d below the surface?

   I The pressure varies directly as the surface area A.

   II The pressure varies directly as the liquid density ρ.

   III The pressure varies inversely as the depth d.

A I only

B II only

C III only

D I and II only

E II and III only

13. The diagram below shows a circuit with a 6·0 V battery connected to two parallel metal plates A and B which are 0·30 m apart.

6·0 V

0·30 m

A   B

The amount of work needed to move 2 coulombs of charge from plate A to plate B is

A   1·8 J
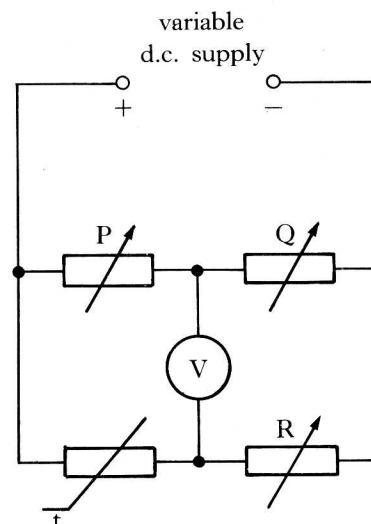
B   3·0 J

C   6·0 J

D   12·0 J

E   20·0 J.

14. The diagram below shows the screen and the settings of an oscilloscope, which is being used to measure the output frequency of a signal generator.

y-gain (V div^{-1})   time base (s div^{-1})   input

What is the frequency of the signal applied to the input of the oscilloscope?

A   2·5 Hz

B   12·5 Hz

C   40 Hz

D   250 Hz

E   500 Hz

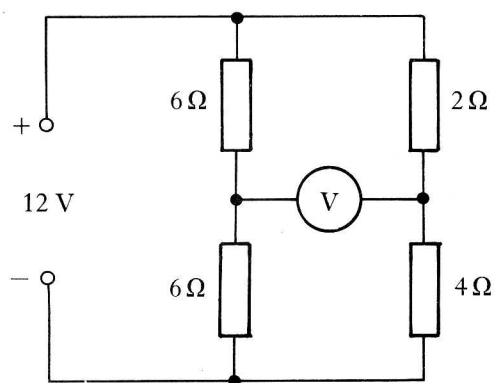**15.** A Wheatstone bridge containing a thermistor is set up as shown below.

The resistance of the thermistor decreases as the temperature increases.

The variable resistor R is adjusted so that the bridge is balanced at a room temperature of 18 °C.

The thermistor is now placed in a beaker containing melting ice. Which adjustment could restore the bridge to its balanced condition?

A   Increasing the resistance of R

B   Decreasing the resistance of R

C   Reducing the resistance of P

D   Increasing the resistance of Q

E   Increasing the supply voltage

16. The bridge circuit below is set up.

The reading on the voltmeter will be

A   0 V

B   2 V

C   6 V

D   8 V

E   12 V.

17. The diagram below represents an alternating voltage.

voltage/V

The corresponding r.m.s. voltage is

A   5 V

B $\dfrac{10}{\sqrt{2}}$ V

C   10 V

D $10\sqrt{2}$ V

E   20 V.

18. The farad is the unit of capacitance.
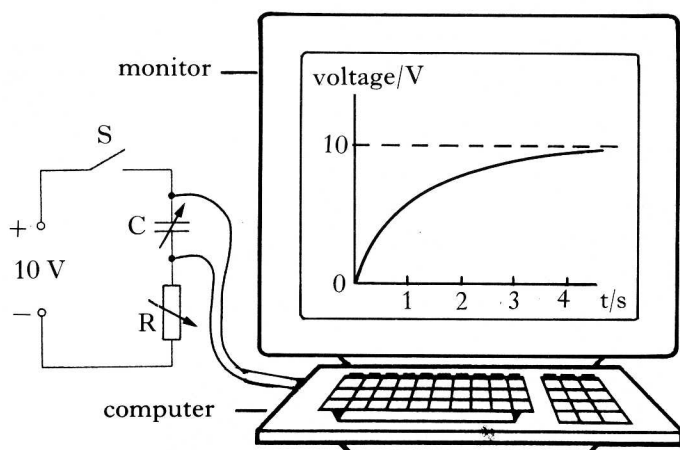
Which of the following units is equivalent to the farad?

A $C\,V^{-1}$

B $J\,C^{-1}$

C $A\,V^{-1}$

D $J\,s^{-1}$

E $C\,s^{-1}$

19. A capacitor is marked 10 V, 100 μF.

The charge stored in the capacitor when it is used at its rated voltage is

A $1 \times 10^{-5}\,C$

B $1 \times 10^{-3}\,C$

C $5 \times 10^{-3}\,C$

D $1 \times 10^{3}\,C$

E $1 \times 10^{5}\,C$.

20. The diagram below shows an experiment in which a computer is used to draw a voltage–time graph for the charging of a capacitor from a supply of e.m.f. 10 V. The supply has negligible internal resistance.
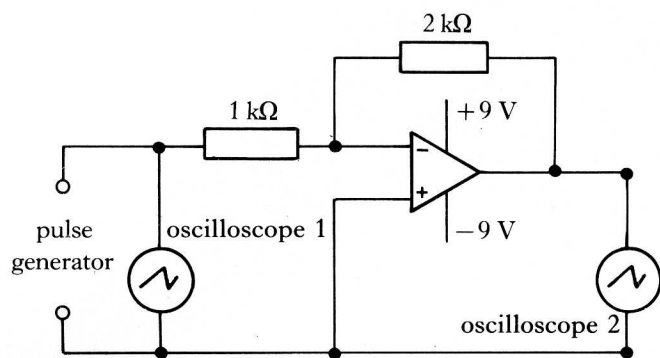

When the switch S is closed, a graph appears on the monitor screen as shown. Switch S is then opened. The capacitor is fully discharged and the values of C and R are both **increased**. Switch S is now closed again.
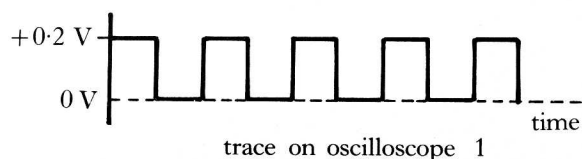
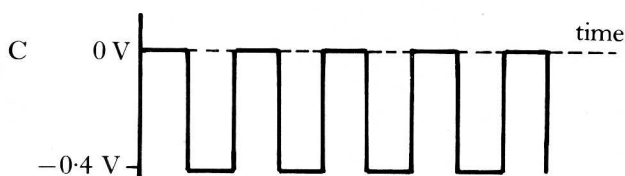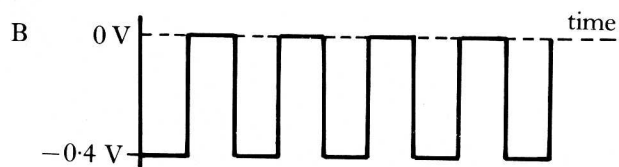If no other changes are made, which of the following graphs appears on the monitor screen?
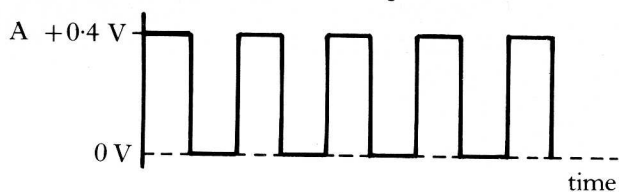
A

B

C

D

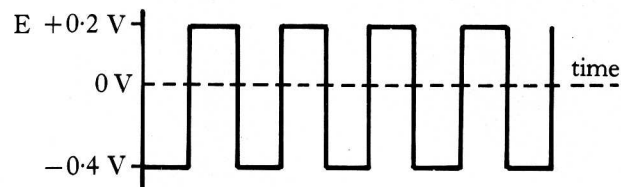
E

21. An ideal operational amplifier is connected as shown.
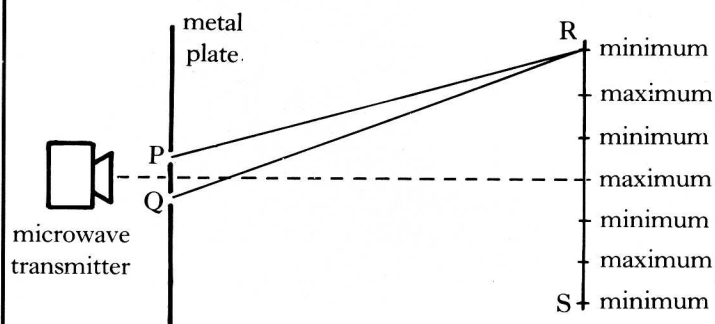

Oscilloscope 1 monitors the following input signal.

trace on oscilloscope 1

For this input signal, which output signal would be monitored on oscilloscope 2?

A

B

C

(D and E are in the next column)

D

E

22. A microwave transmitter is directed at a metal plate which has two slits P and Q in it as shown. The microwave radiation emitted has a wavelength of 3 cm.
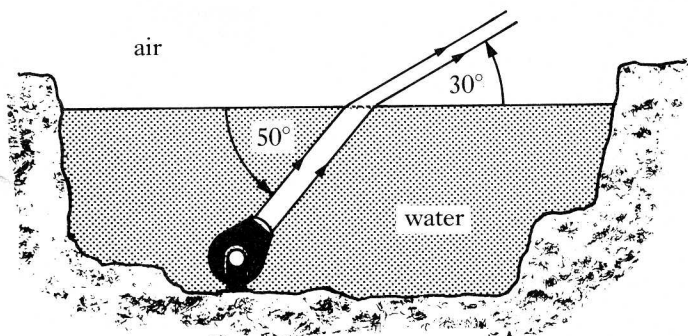

A microwave receiver is moved from R to S and, in doing so, detects maxima and minima of intensity at the positions shown.

What is the path difference between PR and QR?

A   1·5 cm

B   3·0 cm
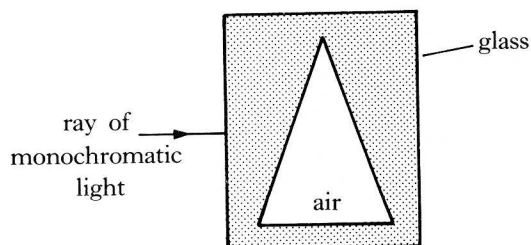
C   4·5 cm

D   6·0 cm

E   9·0 cm

[Turn over

23. The diagram below shows a parallel beam of monochromatic light emerging from an underwater spotlight in an ornamental pond.
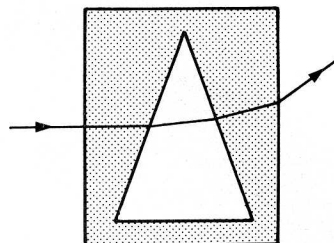

The absolute refractive index of the water in this pond is

A   0·65

B   0·74

C   1·35

D   1·53

E   1·66.

24. Light of frequency $6 \times 10^{14}\,\text{Hz}$ passes from air into glass. The refractive index of the glass is $1 \cdot 5$ and the speed of light in air is $3 \times 10^{8}\,\text{m s}^{-1}$.

The wavelength of this light in the **glass** is

A $5 \cdot 0 \times 10^{-9}\,\text{m}$

B $3 \cdot 3 \times 10^{-7}\,\text{m}$

C $5 \cdot 0 \times 10^{-7}\,\text{m}$

D $7 \cdot 5 \times 10^{-7}\,\text{m}$

E $1 \cdot 8 \times 10^{23}\,\text{m}$.

25. A ray of monochromatic light is directed at right angles into a rectangular glass block as shown below. The centre of the block has a hollow **air-filled** prism shape.
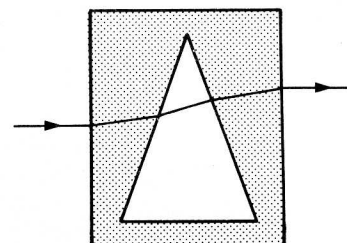

Which diagram correctly shows the path followed by the ray of light as it passes through the block?
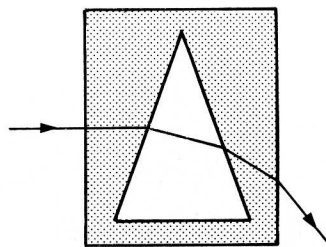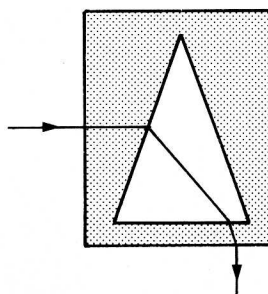
A
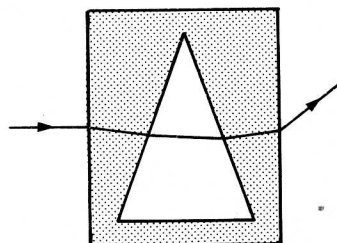

B

C

D

E

26. To demonstrate the photoelectric effect, radiation is directed onto the surface of a clean charged zinc plate.

Which of the following sets of conditions is required to produce the emission of photo-electrons from the zinc plate?

	Charge on zinc plate	Frequency of radiation
A	positive	above a certain value
B	negative	above a certain value
C	positive	any value
D	negative	any value
E	negative	below a certain value

27. A crystal of silicon is "doped" with arsenic, that is, a small number of the silicon atoms are replaced with arsenic atoms.

The effect of the doping on the crystal is to

A   make it into a photodiode

B   make it into an insulator

C   increase its resistance

D   decrease its resistance

E   allow it to conduct in only one direction.

28. Which of the following statements is/are true?

I   In a light emitting diode, positive and negative charge carriers recombine to emit light.

II   In a p–n junction diode, the majority carriers in the p-type material are electrons.

III   In a photodiode, electron-hole pairs are produced by the action of light.

A   I only

B   I and II only

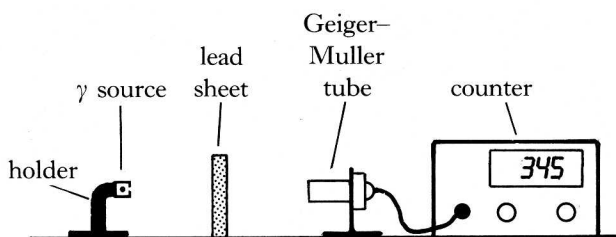C   I and III only

D   II and III only

E   I, II and III

29. The activity of a radioactive source falls to one eighth of its original value in 24 minutes.
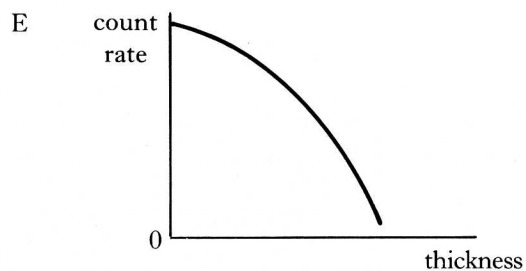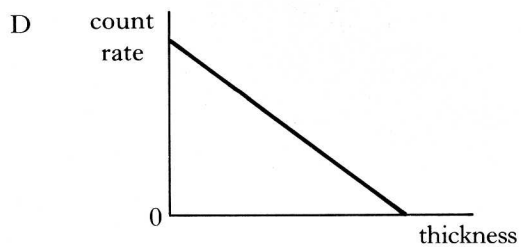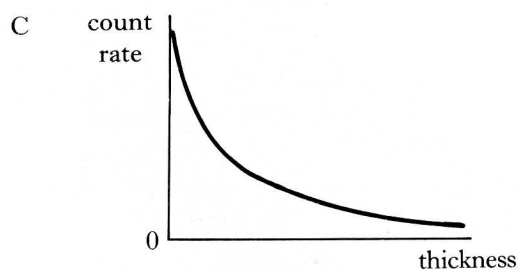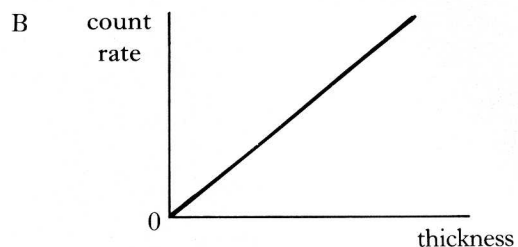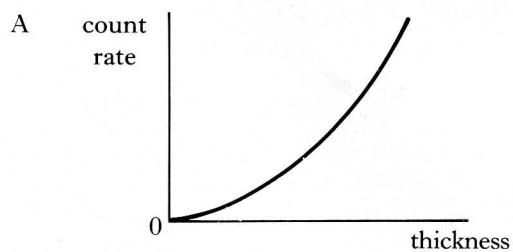
The half-life of this decay process is

A   3 minutes

B   6 minutes

C   8 minutes

D   72 minutes

E   96 minutes.

[Turn over

30. Sheets of lead of different thicknesses are placed between a radioactive source, emitting only gamma radiation, and a Geiger–Muller tube connected to a counter.

Which one of the following graphs shows the variation of count rate with the thickness of lead sheet?
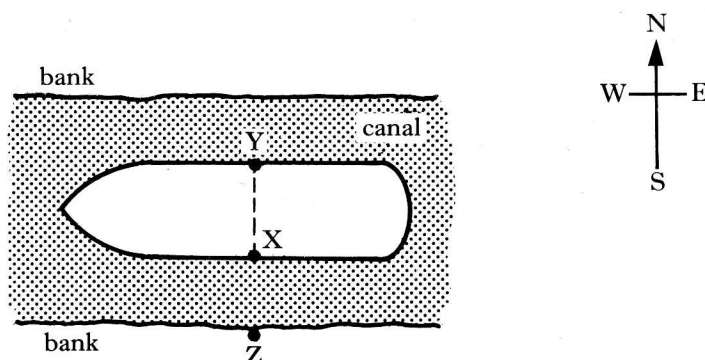
A

B

C

D

E

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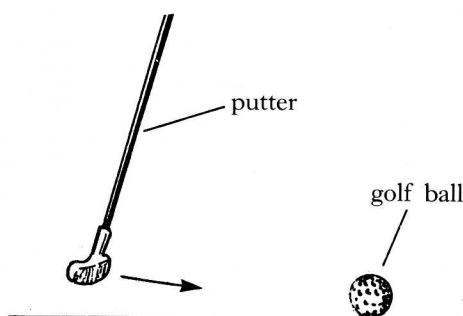
Marks

31. A barge is travelling, with a velocity of $2 \cdot 0\,\mathrm{m\,s}^{-1}$ due west, along a canal. A girl runs, with a speed of $4 \cdot 8\,\mathrm{m\,s}^{-1}$, from X to Y across the deck of the barge as shown below.

By drawing a scale diagram or otherwise, find the resultant velocity of the girl relative to someone at point Z on the bank of the canal.

3

32. A stationary golf ball of mass $0 \cdot 05\,\mathrm{kg}$ is hit by a putter as shown below.
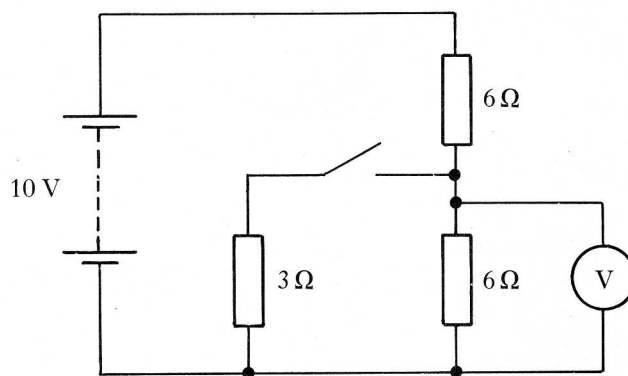

The ball moves off with an initial velocity of $2 \cdot 0\,\mathrm{m\,s}^{-1}$. The time of contact between the putter and ball is measured electronically to be $0 \cdot 060\,\mathrm{s}$.

(*a*) Calculate the average force exerted by the putter on the golf ball.

(*b*) Sketch a possible force–time graph for the impact of the putter with the golf ball.

3

[Turn over

33. The circuit below shows resistors connected as a potential divider.
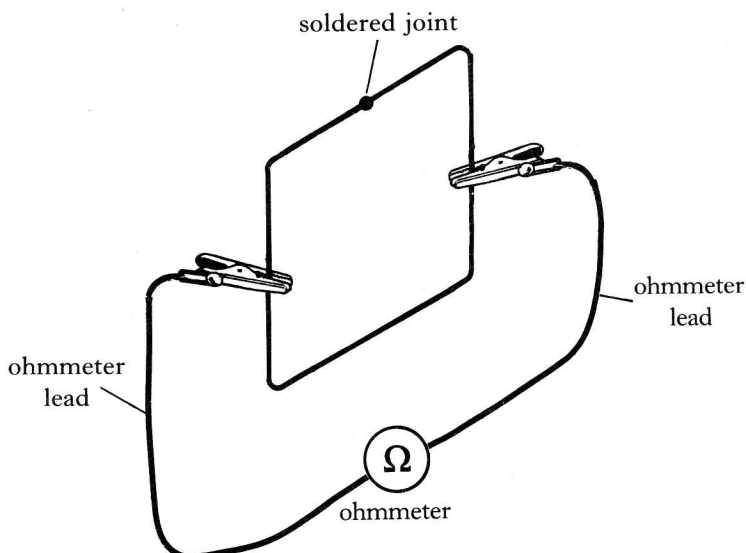

Calculate the reading on the voltmeter

(a)   when the switch is open;

(b)   when the switch is closed.

3

34. The resistance of a length of bare uniform resistance wire is $30\,\Omega$. The length of wire is folded into the shape of a square and the ends soldered together as shown below.
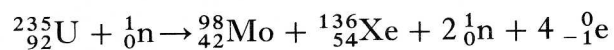

What value of resistance would the ohmmeter read if it is connected as shown at the mid-points of opposite sides of the square?

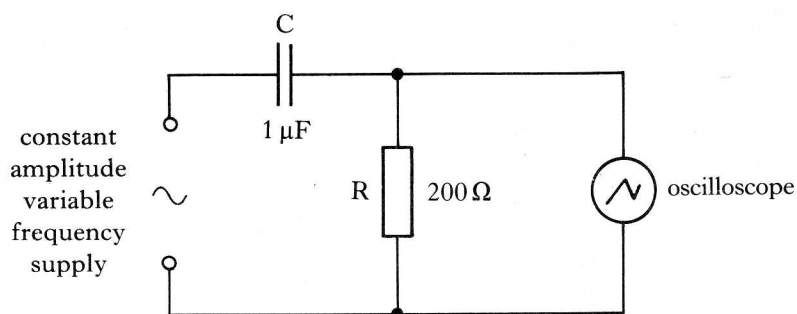(You may ignore the resistance of the ohmmeter leads.)

3

35. A typical reaction produced in the core of a nuclear reactor can be described by the following equation:

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{98}_{42}\text{Mo} + ^{136}_{54}\text{Xe} + 2\,^{1}_{0}\text{n} + 4\,^{0}_{-1}\text{e}$$
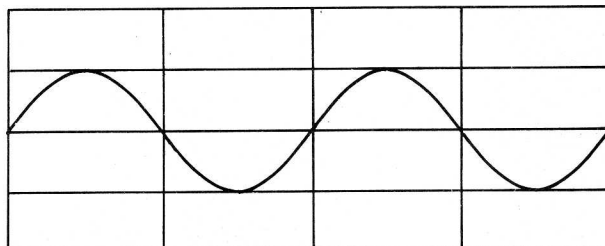
(a)   State the name given to the above type of reaction.

(b)   Large amounts of kinetic energy are released in this reaction.

Explain how this kinetic energy is produced.

3

36. A student sets up the circuit shown below.

When the frequency of the supply is set at 1 kHz, the trace on the oscilloscope is as shown below.

The frequency is now increased to 2 kHz while the oscilloscope controls are left unaltered.

Make a sketch, with grid lines as shown, of the trace you would now expect to see on the oscilloscope.

2

37. The diagram below shows the energy levels for the hydrogen atom.

E_4 —————————	-0.864×10^{-19} J
E_3 —————————	-1.360×10^{-19} J
E_2 —————————	-2.416×10^{-19} J
E_1 —————————	-5.424×10^{-19} J
E_0 —————————	-21.76×10^{-19} J

(a) Between which two energy levels would an electron transition lead to the emission of radiation of **highest** frequency?

(b) Calculate the frequency of the radiation in part (a).

(You may have to refer to the Science Data Booklet.)

3

[END OF QUESTION PAPER]