3220/319

SCOTTISH CERTIFICATE OF EDUCATION 1995

WEDNESDAY, 17 MAY 9.30 AM – 11.00 AM

PHYSICS (REVISED) HIGHER GRADE

Paper I

Read Carefully

1 All questions should be attempted.

2 The following data should be used when required unless otherwise stated.

Speed of light in vacuum c	$3{\cdot}00 \times 10^{8}$ m s^{-1}	Planck's constant h	$6{\cdot}63 \times 10^{-34}$ J s
Charge on electron e	$-1{\cdot}60 \times 10^{-19}$ C	Mass of electron m_e	$9{\cdot}11 \times 10^{-31}$ kg
Acceleration due to gravity g	9·8 m s^{-2}	Mass of proton m_p	$1{\cdot}67 \times 10^{-27}$ 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 38)

9 Answer questions numbered 31 to 38 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 38.

12 Care should be taken **not** to give an unreasonable number of significant figures in the final answers to calculations.

ESB 3220/319 6/3/22810

SCOTTISH EXAMINATION BOARD

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

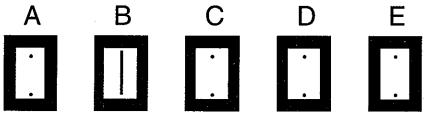
B kilowatt-hour

C watt

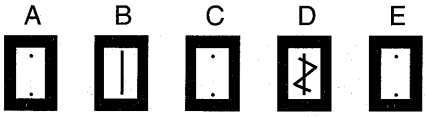
D coulomb

E volt.

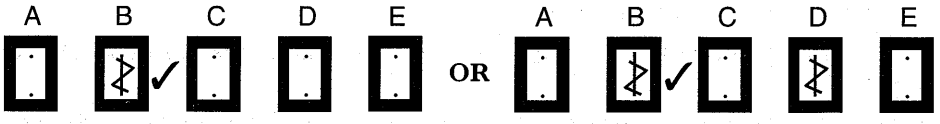
The correct answer to the question is B—kilowatt-hour. Record your answer by drawing a heavy vertical line joining the two dots in the appropriate box on your answer sheet in the column of boxes headed B. The entry on your answer sheet would now look like this:



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. Which one of the following is a vector quantity?

A Distance

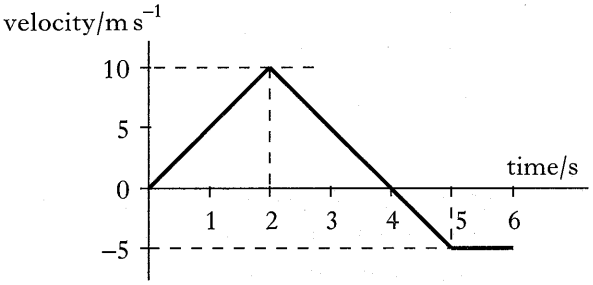
B Time

C Speed

D Energy

E Weight

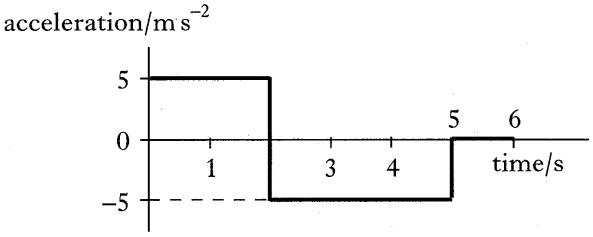
2. The velocity-time graph of the motion of an object starting from rest is shown below.



Which of the following statements about the motion of the object is/are true?

I There is a change of direction of the object at 4 s.

II The acceleration-time graph is of the form shown below.



III The displacement of the object from the starting point is greatest at 6 s.

A I only

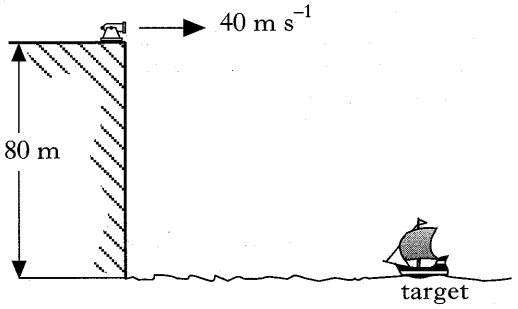
B II only

C I and II only

D I and III only

E II and III only

3. A cannonball is fired horizontally at 40 m s^{-1} from the top of a vertical cliff and it hits its target. The height of the cliff above the level of the sea is 80 m.



How far is the target from the foot of the cliff, if air resistance is negligible and the acceleration due to gravity is 10 m s^{-2}?

A 320 m

B 160 m

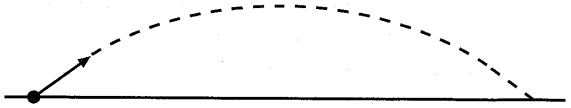
C 80 m

D 45 m

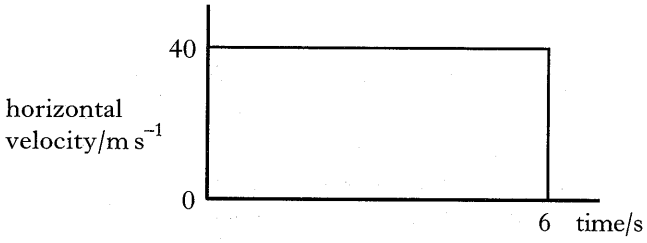
E 40 m

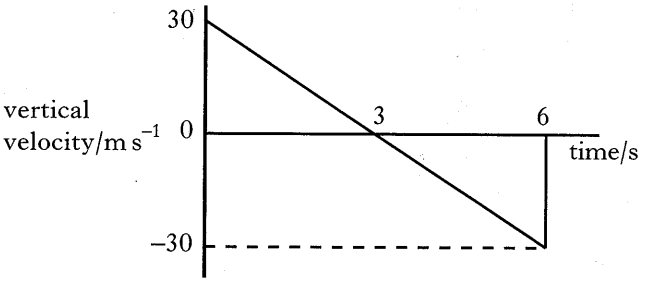
[Turn over

4. A golfer strikes a golf ball which then moves off at an angle to the ground. The ball, following the path shown below, lands 6 s later.



The graphs below show how the ball's horizontal and vertical components of velocity vary with time, the acceleration due to gravity being $10\,m\,s^{-2}$.





What is the speed of the ball just before it hits the ground?

A $10\,m\,s^{-1}$

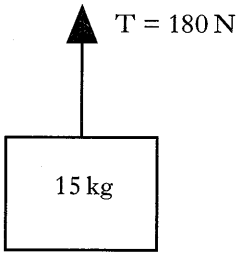
B $30\,m\,s^{-1}$

C $40\,m\,s^{-1}$

D $50\,m\,s^{-1}$

E $70\,m\,s^{-1}$

5. A tension force of 180 N is applied vertically upwards to a box of mass 15 kg.



Assuming that the acceleration due to gravity is $10\,m\,s^{-2}$, the acceleration of the box is

A $2\,m\,s^{-2}$

B $8\,m\,s^{-2}$

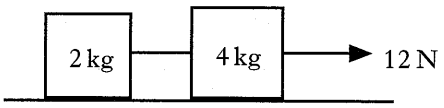
C $10\,m\,s^{-2}$

D $12\,m\,s^{-2}$

E $20\,m\,s^{-2}$.

6. Two boxes on a frictionless horizontal surface are joined together by a string, as shown.

The 4 kg box is being pulled to the right by a constant horizontal force of 12 N.



What is the value of the force of tension in the string joining the two boxes?

A 2 N

B 4 N

C 6 N

D 8 N

E 12 N

7. The total mass of a motorcycle and rider is 250 kg. During braking, they are brought to rest from a speed of $15\,m\,s^{-1}$ in a time of 10 s. The maximum energy which could be converted to heat by the brakes is

A 3 750 J

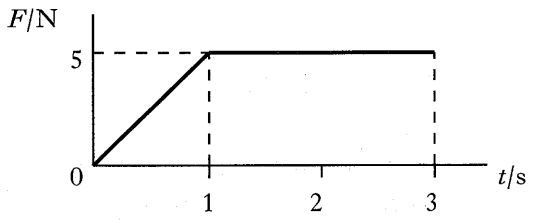
B 28 125 J

C 37 500 J

D 56 250 J

E 375 000 J.

8. A model car of mass 3 kg, initially at rest, is acted upon by an unbalanced force F, as shown in the following force-time graph.



What is the momentum of the model car at time $t = 3$ s?

A 0 kg m s^{-1}

B $2{\cdot}5 \text{ kg m s}^{-1}$

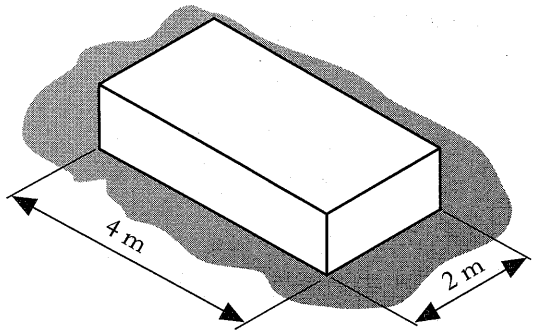
C 5 kg m s^{-1}

D $12{\cdot}5 \text{ kg m s}^{-1}$

E 15 kg m s^{-1}

9. A rectangular box of mass 10 kg is lying on a flat surface on a planet where the gravitational field strength is 4 N kg^{-1}.

The base of the box measures 4 m by 2 m.



Which of the following statements is/are correct?

I The weight of the box is 100 N.

II The weight of the box is 40 N.

III The pressure which the box exerts on the flat surface is 5 Pa.

A I only

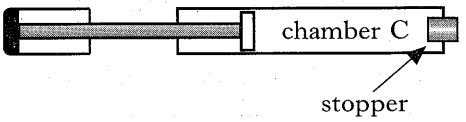
B II only

C III only

D I and III only

E II and III only

10. The end of a bicycle pump is sealed with a small rubber stopper. The air in chamber C is now trapped.



The plunger is then pushed in slowly, causing the air in the chamber C to be compressed. As a result of this, the pressure of the air increases.

Which of the following explain(s) why the pressure increases, assuming that the temperature remains constant?

I The air molecules increase their average speed.

II The air molecules are colliding more often with the walls of the chamber.

III Each air molecule is striking the walls of the chamber with greater force.

A II only

B III only

C I and II only

D I and III only

E I, II and III

11. An electron is accelerated from rest in an electron gun, across a potential difference of 2×10^3 V.

The kinetic energy gained by the electron as it goes through the electron gun is

A $8{\cdot}0 \times 10^{-23}$ J

B $8{\cdot}0 \times 10^{-20}$ J

C $3{\cdot}2 \times 10^{-19}$ J

D $1{\cdot}6 \times 10^{-16}$ J

E $3{\cdot}2 \times 10^{-16}$ J.

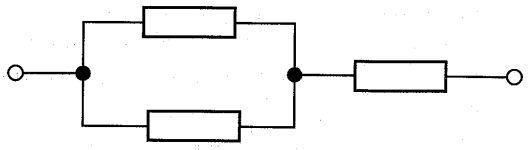
[Turn over

12. A student requires a resistor for an electronics project and its value must lie in the range $(15 \pm 3)\ \Omega$.

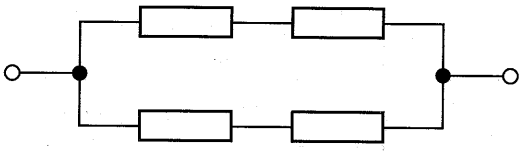
The only resistors available have values of exactly $10\ \Omega$.

Which of the following combinations of these $10\ \Omega$ resistors could be used?

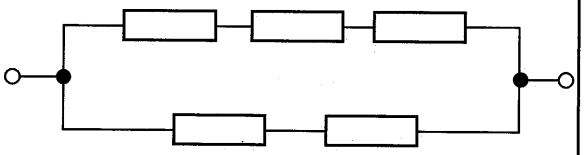
I



II



III



A I only

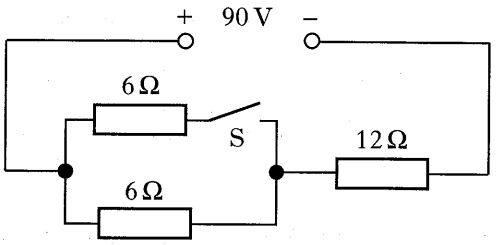
B I and II only

C I and III only

D II and III only

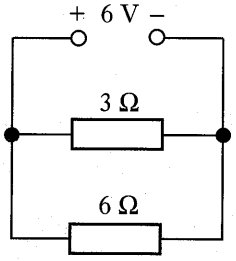
E I, II and III

13. In the following circuit, what is the potential difference across the $12\ \Omega$ resistor when the switch S is (i) open, and (ii) closed? The supply has negligible internal resistance.



	(i) p.d. when switch S open	*(ii) p.d. when switch S closed*
A	30 V	18 V
B	45 V	45 V
C	60 V	45 V
D	60 V	72 V
E	72 V	60 V

14. The circuit below shows two resistors connected to a 6 V d.c. supply of negligible internal resistance.



The power dissipated in the $3\ \Omega$ resistor is

A 3 W

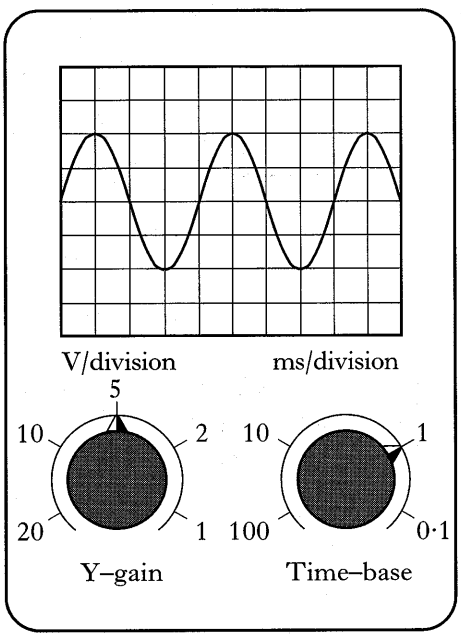
B 6 W

C 9 W

D 12 W

E 18 W.

15. An alternating voltage signal is displayed on an oscilloscope, with the settings shown.



Which row in the following table gives the correct values for the peak voltage and frequency of the signal?

	Peak Voltage/V	*Frequency*/Hz
A	10	100
B	10	250
C	20	250
D	10	500
E	20	1000

16. The heating element in a boiler operates at 2400 W from a 120 V r.m.s. power supply.

What is the r.m.s. current, in amperes, in this element?

A 10

B $\frac{20}{\sqrt{2}}$

C 20

D $20\sqrt{2}$

E 40

17. The "coulomb per volt" is a unit of

A charge

B energy

C power

D capacitance

E potential difference.

18. The energy stored in a 500 μF capacitor charged to a voltage of 20 V is

A 5×10^{-3} J

B $2{\cdot}5\times10^{-2}$ J

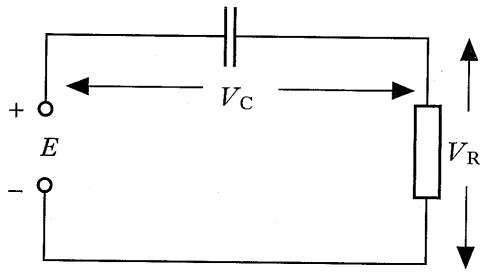
C 5×10^{-2} J

D 1×10^{-1} J

E 2×10^{-1} J.

[Turn over

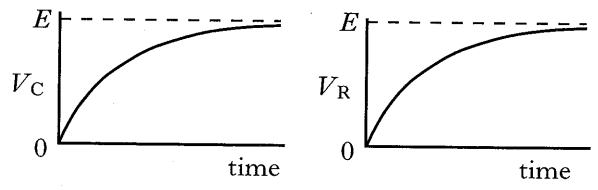
19. In the following circuit, a capacitor is being charged up from a d.c. source of e.m.f. E. The capacitor has a resistor in series with it, as shown.



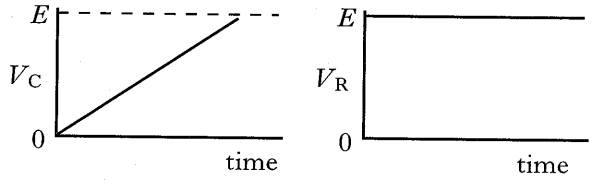
The voltages, V_C and V_R, across the components are recorded at regular time intervals as the capacitor charges up.

Which of the pairs of graphs shown below correctly represents the voltages across the capacitor and the resistor during charging?

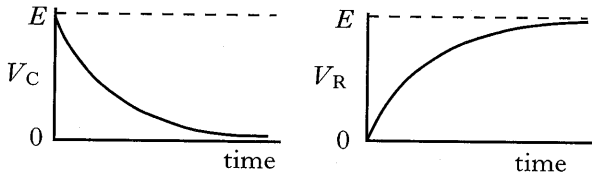
A



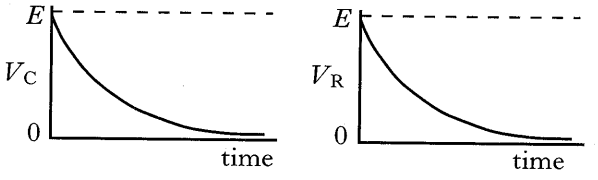
B



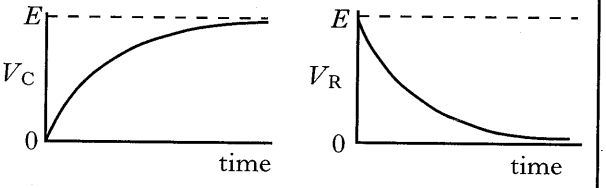
C



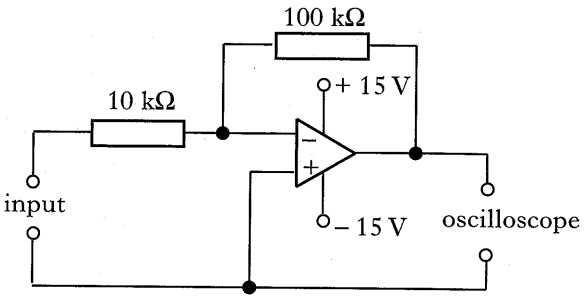
D



E



20. An oscilloscope is used to measure the frequency of the output voltage from an operational amplifier.



The input voltage has a frequency of 280 Hz and a peak value of 0·5 V.

The frequency of the output voltage is

A 14 Hz

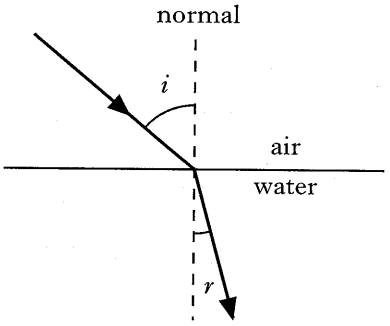
B 28 Hz

C 280 Hz

D 560 Hz

E 2800 Hz.

21. A ray of light passing from air into water is refracted towards the normal.



Which of the following statements is/are true?

I The speed of the light in water is less than the speed of the light in air.

II The frequency of the light in water is less than the frequency of the light in air.

III The wavelength of the light in water is less than the wavelength of the light in air.

A I only

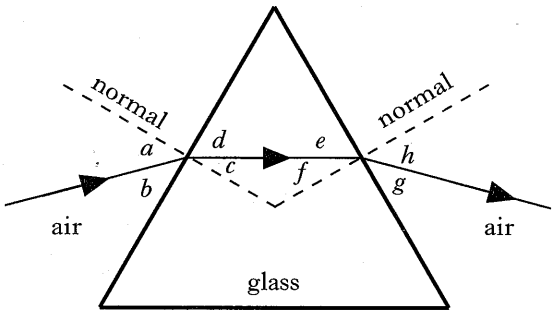
B III only

C I and II only

D I and III only

E I, II and III

22. A ray of monochromatic light is directed towards a glass prism and travels through it.



Which of the following expressions can be used to calculate the refractive index of the glass used for this prism?

A $\frac{\sin c}{\sin a}$

B $\frac{\sin b}{\sin c}$

C $\frac{\sin f}{\sin h}$

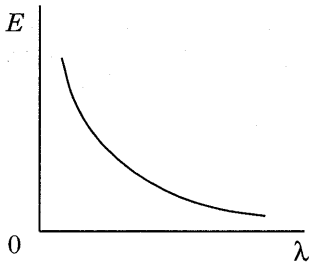
D $\frac{\sin h}{\sin f}$

E $\frac{\sin e}{\sin h}$

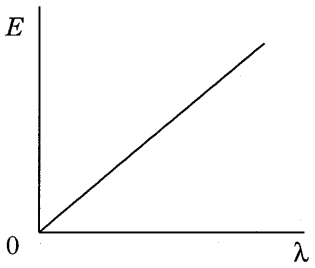
23. The energy, E, of a photon of light depends on its wavelength λ.

Which of the following graphs correctly illustrates the relationship between E and λ?

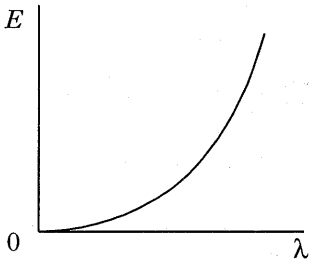
A



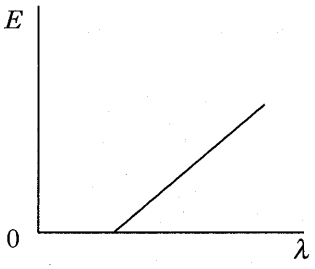
B



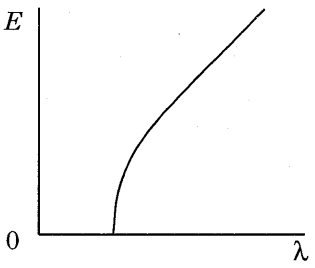
C



D



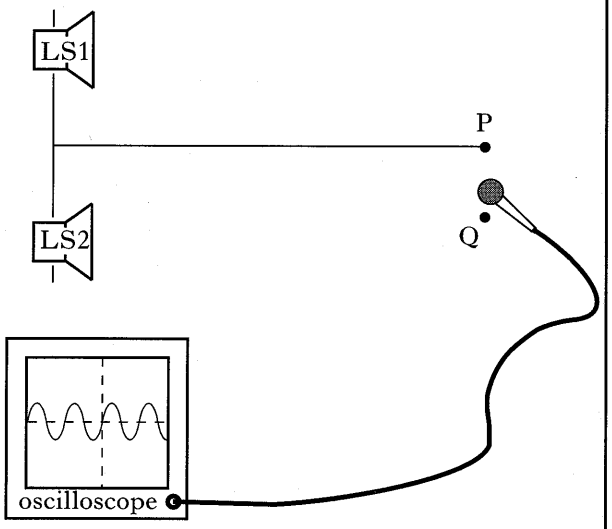
E



[Turn over

24. Two loudspeakers LS1 and LS2, connected to the same output of a signal generator, provide coherent sources of sound waves. A microphone, connected to an oscilloscope, is used to detect the sound.

Position P is the same distance from LS1 as it is from LS2. Position Q is **one wavelength** of the sound wave further from LS1 than it is from LS2.



Which of the following best describes what happens to the oscilloscope trace as the microphone is slowly moved from position P to position Q?

A Constant amplitude of trace when moved from P to Q

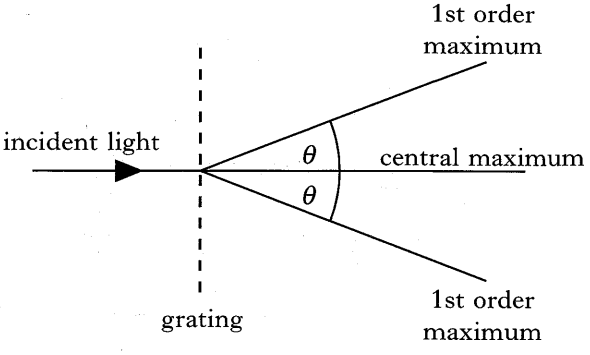
B Minimum amplitude at P increasing to maximum amplitude at Q

C Maximum amplitude at P decreasing to minimum amplitude at Q

D Minimum amplitude at P, going through a maximum and then back to a minimum amplitude at Q

E Maximum amplitude at P, going through a minimum and then back to a maximum amplitude at Q

25. When monochromatic light is passed through a grating, a pattern of maxima and minima is observed as shown below.



Which row in the following table represents the arrangement which would produce the greatest angle θ between the central and first order maxima?

	Grating (lines per mm)	*Colour of light*
A	100	Red
B	100	Green
C	100	Blue
D	200	Red
E	200	Blue

26. A point source S emits radiation equally in all directions.

Source

S P Q

The distance from S to Q is nine times the distance from S to P.

The intensity of radiation at P is I. The intensity at point Q is

A $9I$

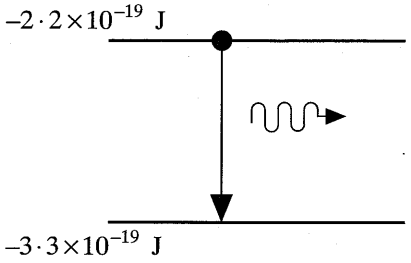
B $3I$

C $\frac{I}{3}$

D $\frac{I}{9}$

E $\frac{I}{81}$.

27. In a laser, a photon of light is emitted when an electron makes a transition from a higher energy level to a lower one, as shown below.



If the energy in each pulse of light from the laser is 10 J, how many photons are there in each pulse?

A $\dfrac{10}{5\cdot5\times10^{-19}}$

B $\dfrac{10}{(1\cdot1+1\cdot6)\times10^{-19}}$

C $\dfrac{10}{3\cdot3\times10^{-19}}$

D $\dfrac{10}{2\cdot2\times10^{-19}}$

E $\dfrac{10}{1\cdot1\times10^{-19}}$

28. An element X emits an alpha particle to form a new element.

Which of the following statements is/are correct about this **new** element?

I The total number of protons and neutrons is 4 less than in element X.

II The number of protons is the same as in element X.

III The new element is an isotope of element X.

A I only

B II only

C III only

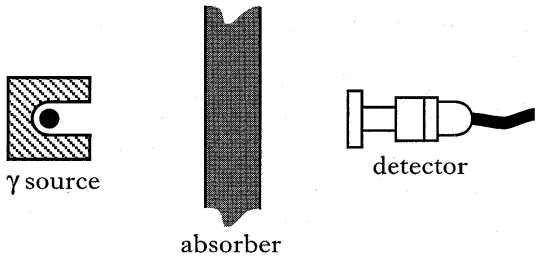
D I and III only

E II and III only

29. Which row in the following table shows the correct units for all three quantities listed?

	Absorbed Dose	*Dose Equivalent*	*Activity*
A	gray	sievert	becquerel
B	becquerel	gray	sievert
C	sievert	becquerel	gray
D	sievert	gray	becquerel
E	gray	becquerel	sievert

30. A 60 mm thick lead absorber is placed between a gamma source and a detector. The reading measured by the detector is 240 Bq. The half-value thickness of the lead is 30 mm.



What will the reading be if the 60 mm absorber is replaced by one of thickness 120 mm?

A 120 Bq

B 80 Bq

C 60 Bq

D 40 Bq

E 30 Bq

[Turn over

SECTION B

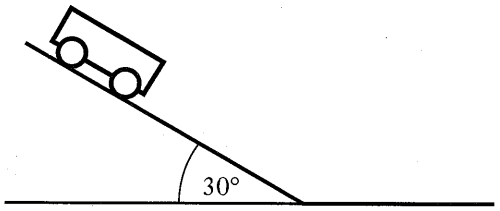
Write your answers to questions 31 to 38 in the answer book.

Marks

31. An advertising brochure for a car gives the information that the car, starting from rest, can cover 400 m in 17·5 s under constant acceleration.

Calculate the acceleration of the car. **2**

32. A trolley of mass 2·0 kg rolls down a slope which makes an angle of 30° with the horizontal.



The constant frictional force opposing the motion is 4·0 N.

Calculate the size of the resultant force, in newtons, acting on the trolley. **2**

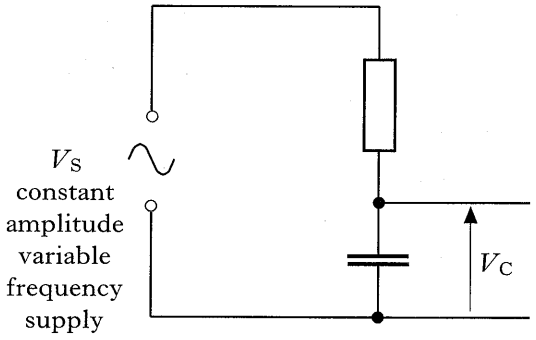
33. A skin diver carries her air supply in a steel cylinder on her back. She works at a depth where the pressure is $2{\cdot}5\times10^5$ Pa. When full, the cylinder contains $0{\cdot}060\,m^3$ of air at a pressure of $1{\cdot}6\times10^7$ Pa.

Calculate the volume of air available to her at this depth from a full cylinder. **3**

34. The potential difference across a lamp is 12 V.

How much energy is dissipated in the lamp when a charge of 5 C passes through it? **2**

35. A resistor and capacitor are connected in series with an a.c. supply of voltage V_S as shown below. A voltage V_C is produced across the capacitor. The frequency of the supply can be changed.

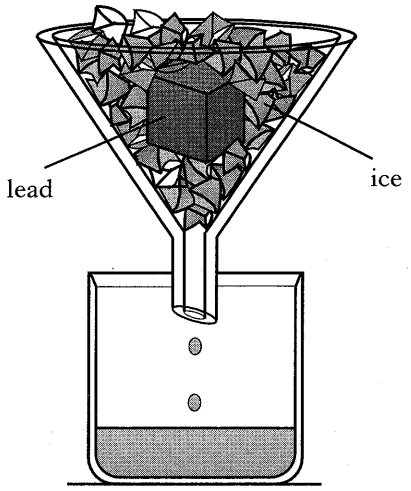


When the frequency of the supply is 100 Hz, the ratio V_C/V_S equals 0·5. The frequency of the supply voltage V_S is now increased to 1000 Hz while its amplitude is kept constant.

State whether the ratio V_C/V_S will increase, decrease or be unchanged. Justify your answer. **2**

Marks

36. A student uses the following method to determine the specific heat capacity of lead. He places some hot lead into a filter funnel containing ice at 0 °C as shown.



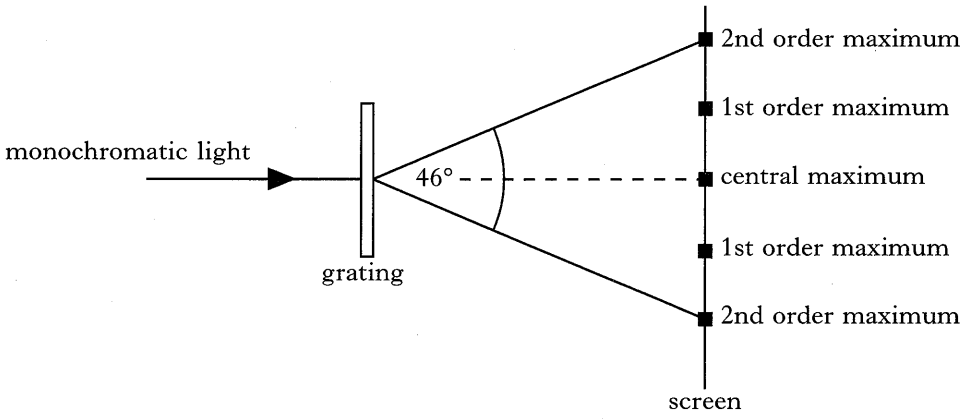
He measures the mass of water which collects in the beaker.

(*a*) What additional data would the student require to obtain a value for the specific heat capacity of lead?

(*b*) Using this method, the student obtains a value for the specific heat capacity of lead which is greater than the accepted value.

Suggest the reason for this difference. **3**

37. Monochromatic light is incident normally upon a grating which has 300 lines per mm. The angle between the two second order maxima is 46° as shown below.



(*a*) Calculate the wavelength of the monochromatic light.

(*b*) What is the colour of this light? **3**

38. The following results were obtained for the half-life of a particular radioactive isotope:

53·0 s, 54·1 s, 57·5 s, 56·3 s, 55·1 s.

Calculate the best estimate of the half-life and the approximate random error in this value. **3**

[END OF QUESTION PAPER]