X069/11/02

NATIONAL QUALIFICATIONS 2013

MONDAY, 27 MAY 1.00 PM – 3.00 PM

PHYSICS INTERMEDIATE 2

Read Carefully

Reference may be made to the Physics Data Booklet

1 All questions should be attempted.

Section A (questions 1 to 20)

2 Check that the answer sheet is for Physics Intermediate 2 (Section A).

3 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.

4 Check that the answer sheet you have been given has **your name**, **date of birth**, **SCN** (Scottish Candidate Number) and **Centre Name** printed on it.

Do not change any of these details.

5 If any of this information is wrong, tell the Invigilator immediately.

6 If this information is correct, **print** your name and seat number in the boxes provided.

7 There is **only one correct** answer to each question.

8 Any rough working should be done on the question paper or the rough working sheet, **not** on your answer sheet.

9 At the end of the exam, **put the answer sheet for Section A inside the front cover of your answer book**.

10 Instructions as to how to record your answers to questions 1–20 are given on page three.

Section B (questions 21 to 31)

11 Answer the questions numbered 21 to 31 in the answer book provided.

12 **All answers must be written clearly and legibly in ink.**

13 Fill in the details on the front of the answer book.

14 Enter the question number clearly in the margin of the answer book beside each of your answers to questions 21 to 31.

15 Care should be taken to give an appropriate number of significant figures in the final answers to calculations.

DATA SHEET

Speed of light in materials

Material	*Speed* in m/s
Air	$3{\cdot}0 \times 10^8$
Carbon dioxide	$3{\cdot}0 \times 10^8$
Diamond	$1{\cdot}2 \times 10^8$
Glass	$2{\cdot}0 \times 10^8$
Glycerol	$2{\cdot}1 \times 10^8$
Water	$2{\cdot}3 \times 10^8$

Speed of sound in materials

Material	*Speed* in m/s
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Gravitational field strengths

	Gravitational field strength on the surface in N/kg
Earth	10
Jupiter	26
Mars	4
Mercury	4
Moon	1·6
Neptune	12
Saturn	11
Sun	270
Venus	9

Specific heat capacity of materials

Material	*Specific heat capacity* in J/kg °C
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion* in J/kg
Alcohol	$0{\cdot}99 \times 10^5$
Aluminium	$3{\cdot}95 \times 10^5$
Carbon Dioxide	$1{\cdot}80 \times 10^5$
Copper	$2{\cdot}05 \times 10^5$
Iron	$2{\cdot}67 \times 10^5$
Lead	$0{\cdot}25 \times 10^5$
Water	$3{\cdot}34 \times 10^5$

Melting and boiling points of materials

Material	*Melting point* in °C	*Boiling point* in °C
Alcohol	–98	65
Aluminium	660	2470
Copper	1077	2567
Glycerol	18	290
Lead	328	1737
Iron	1537	2737

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation* in J/kg
Alcohol	$11{\cdot}2 \times 10^5$
Carbon Dioxide	$3{\cdot}77 \times 10^5$
Glycerol	$8{\cdot}30 \times 10^5$
Turpentine	$2{\cdot}90 \times 10^5$
Water	$22{\cdot}6 \times 10^5$

Radiation weighting factors

Type of radiation	*Radiation weighting factor*
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3

SECTION A

For questions 1 to 20 in this section of the paper the answer to each question is either A, B, C, D or E. Decide what your answer is, then, using your pencil, put a horizontal line in the space provided—see the example below.

EXAMPLE

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

A kilowatt-hour

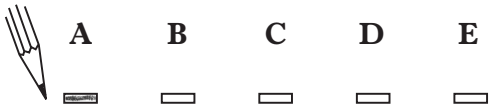
B ampere

C watt

D coulomb

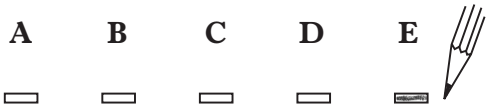
E volt.

The correct answer is **A—**kilowatt-hour. The answer **A** has been clearly marked in **pencil** with a horizontal line (see below).



Changing an answer

If you decide to change your answer, carefully erase your first answer and, using your pencil, fill in the answer you want. The answer below has been changed to **E**.



[Turn over

SECTION A

Answer questions 1–20 on the answer sheet.

1. Which row contains two scalar quantities and one vector quantity?

A Distance, momentum, velocity

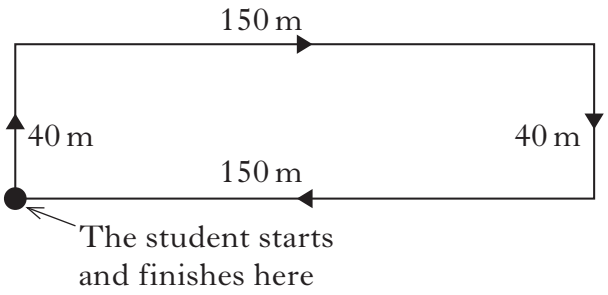
B Speed, mass, momentum

C Distance, weight, force

D Speed, weight, momentum

E Velocity, force, mass

2. A student follows the route shown in the diagram and arrives back at the starting point.



Which row in the table shows the total distance walked and the magnitude of the final displacement?

	Total distance (m)	*Final displacement* (m)
A	0	80
B	0	380
C	190	0
D	380	0
E	380	380

3. A space probe has a mass of 60 kg. The weight of the space probe at the surface of a planet in our solar system is 720 N.

The planet is

A Venus

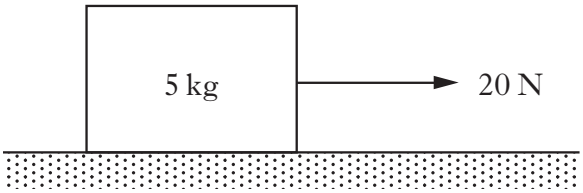
B Mars

C Jupiter

D Saturn

E Neptune.

4. A block is pulled across a horizontal surface as shown.



The mass of the block is 5 kg.

The block is travelling at a constant speed.

The force of friction acting on the block is

A 0 N

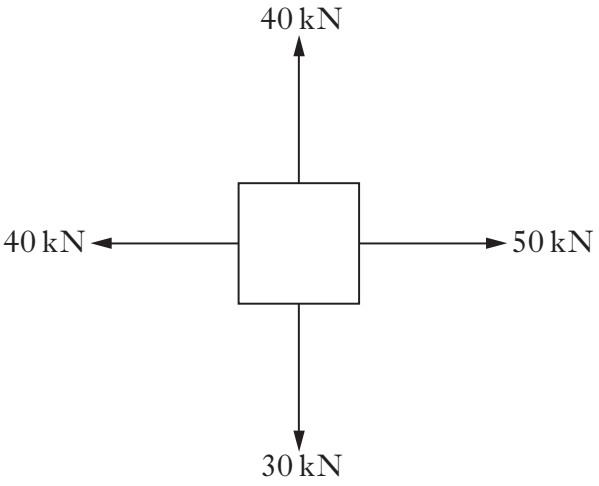
B 4 N

C 15 N

D 20 N

E 25 N.

5. Four tugs apply forces to an oil-rig in the directions shown.



Which of the following could represent the direction of the resultant force?

A

B

C

D

E

6. The specific latent heat of fusion of a substance is the energy required to

A melt 1 kg of the substance at its melting point

B evaporate 1 kg of the substance at its boiling point

C change the state of the substance without changing its temperature

D change the temperature of the substance without changing its state

E change the temperature of 1 kg of the substance by 1 °C.

7. A block of ice of mass 1·5 kg is placed in a room.

The temperature of the block is 0 °C.

The temperature of the room is 20 °C.

The minimum energy required to **melt** the ice is

A $0{\cdot}63 \times 10^5$ J

B $1{\cdot}25 \times 10^5$ J

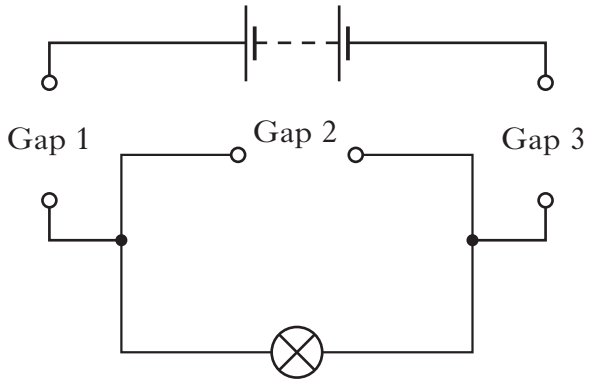
C $1{\cdot}88 \times 10^5$ J

D $5{\cdot}01 \times 10^5$ J

E $6{\cdot}26 \times 10^5$ J.

[Turn over

8. A circuit with three gaps is shown below.

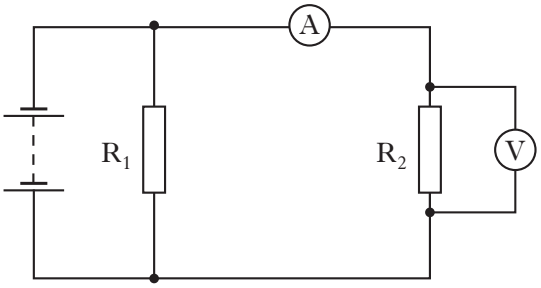


Which row in the table shows the combination of conductors and insulators that should be placed in the gaps to allow the lamp to light?

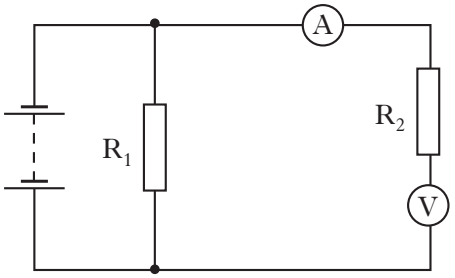
	Gap 1	*Gap 2*	*Gap 3*
A	conductor	insulator	conductor
B	conductor	conductor	insulator
C	conductor	conductor	conductor
D	insulator	insulator	conductor
E	insulator	insulator	insulator

9. In which circuit below would the meter readings allow the resistance of R_2 to be calculated?

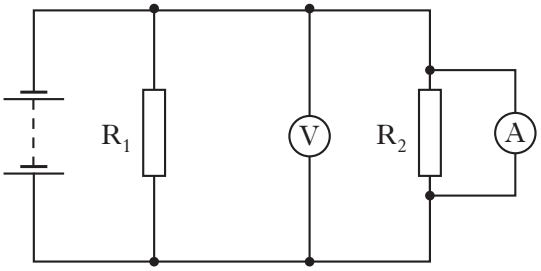
A



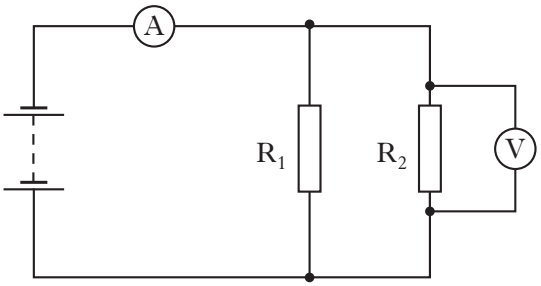
B



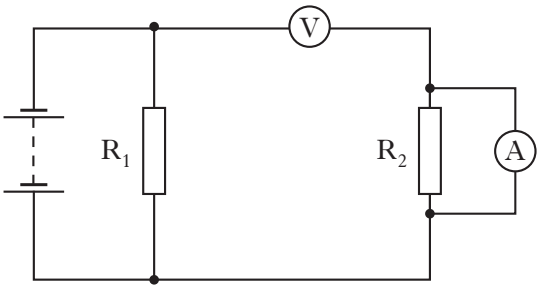
C



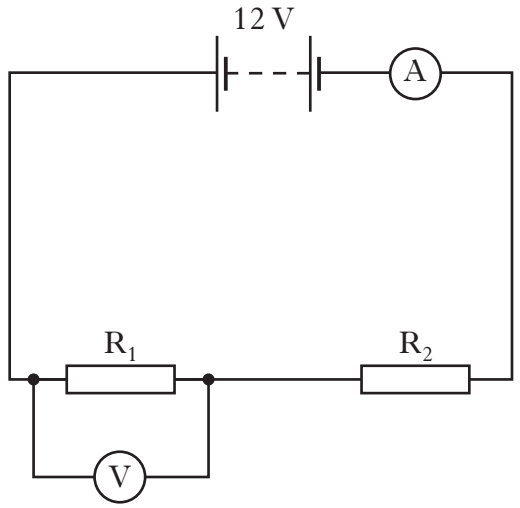
D



E



10. A circuit is set up as shown.



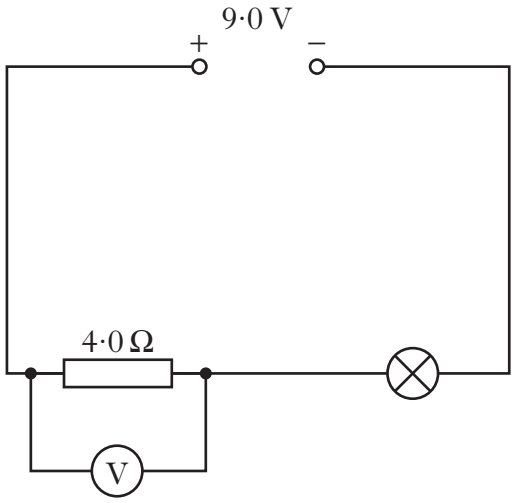
The reading on the ammeter is 3·0 A.

The reading on the voltmeter is 4·0 V.

Which row in the table shows the current in resistor R_2 and the voltage across resistor R_2?

	Current in resistor R_2 (A)	*Voltage across resistor R_2* (V)
A	1·5	8·0
B	3·0	4·0
C	3·0	8·0
D	1·5	12·0
E	6·0	4·0

11. A circuit is set up as shown.



The current in the lamp is 1·5 A.

The reading on the voltmeter is 6·0 V.

The power developed in the lamp is

A 3·0 W

B 4·5 W

C 6·0 W

D 9·0 W

E 13·5 W.

12. Which of the following devices converts heat energy into electrical energy?

A Solar cell

B Resistor

C Thermocouple

D Thermistor

E Transistor

[Turn over

13. Which of the following electromagnetic waves has a higher frequency than microwaves and a lower frequency than visible light?

A Gamma rays

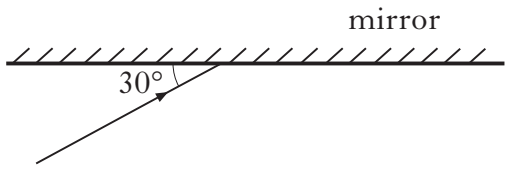
B Infrared

C Radio

D Ultraviolet

E X-rays

14. A ray of light is incident on a plane mirror as shown.

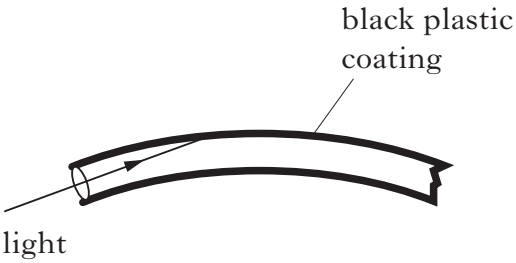


The ray of light reflects from the mirror.

Which row in the table shows the values of the angle of incidence and the angle of reflection?

	Angle of incidence	*Angle of reflection*
A	30°	30°
B	30°	60°
C	30°	150°
D	60°	30°
E	60°	60°

15. The diagram shows a ray of light in an optical fibre.



A student makes the following statements about light transmitted along the optical fibre.

I The light is totally internally reflected inside the glass.

II The light is reflected by the black plastic coating.

III The angle of incidence in the glass is greater than the critical angle for this glass.

Which of the statements is/are correct?

A I only

B III only

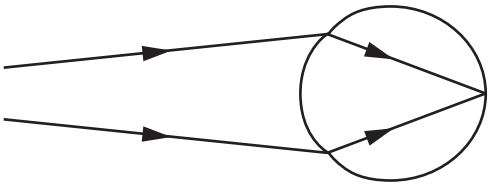
C I and II only

D I and III only

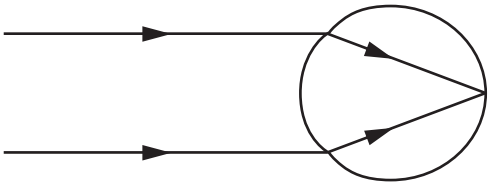
E I, II and III

16. Which of the following diagrams shows the focusing of rays of light from a distant object by the eye of a long-sighted person?

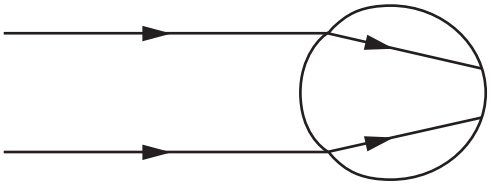
A



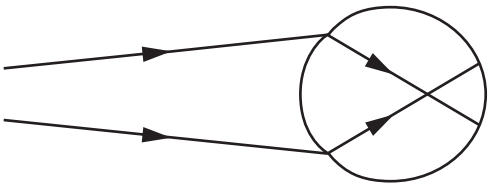
B



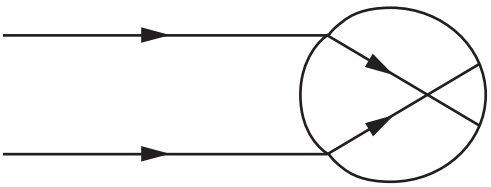
C



D



E



17. A student makes the following statements.

I The nucleus of an atom contains protons and electrons.

II Gamma radiation produces the greatest ionisation density.

III Beta particles are fast moving electrons.

Which of the statements is/are correct?

A I only

B II only

C III only

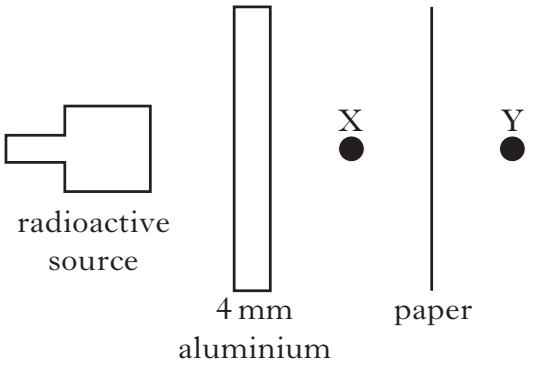
D I and III only

E II and III only

[Turn over

18. A radioactive source emits α, β and γ radiation.

Sheets of aluminium and paper are placed close to the source as shown.



Which row in the table shows the radiation(s) from the source detected at points X and Y?

	Radiation(s) detected at X	*Radiation detected at Y*
A	α, γ	γ
B	β,γ	α
C	α	β
D	β	γ
E	γ	γ

19. Which of the following describes the term ionisation?

A An atom losing an orbiting electron.

B An atom losing a proton.

C A nucleus emitting an alpha particle.

D A nucleus emitting a neutron.

E A nucleus emitting a gamma ray.

20. A student makes the following statements about radiation.

I The half life of a radioactive source is half of the time it takes for its activity to reduce to zero.

II The activity of a radioactive source is the number of decays per minute.

III The risk of biological harm from radiation depends on the type of tissue exposed.

Which of the statements is/are correct?

A I only

B II only

C III only

D II and III only

E I, II and III

Candidates are reminded that the answer sheet for Section A MUST be placed INSIDE the front cover of the answer book.

SECTION B

Marks

Write your answers to questions 21–31 in the answer book.

All answers must be written clearly and legibly in ink.

21. A plane of mass 750 kg is at rest on a runway. The engine applies a force of 4·50 kN.

(*a*) Calculate the magnitude of the acceleration of the plane assuming there are no other forces acting on the plane at this point. **2**

(*b*) The required speed for take-off is 54 m/s.

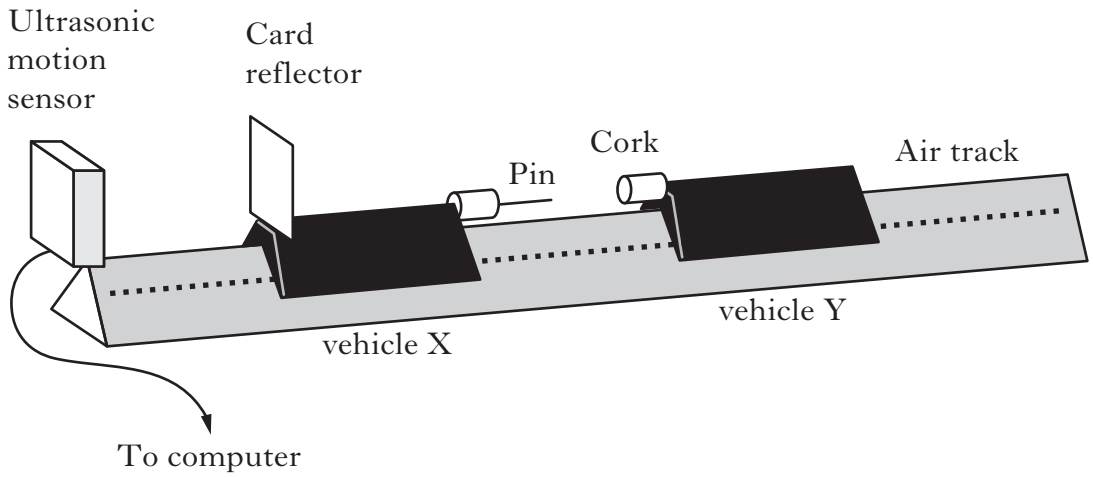
Calculate the time it takes to reach this speed assuming the acceleration is constant. **2**

(*c*) In practice the acceleration is not constant. Give a reason for this. **1**

(5)

[Turn over

22. A student uses a linear air track and an ultrasonic motion sensor to investigate a collision between two vehicles.



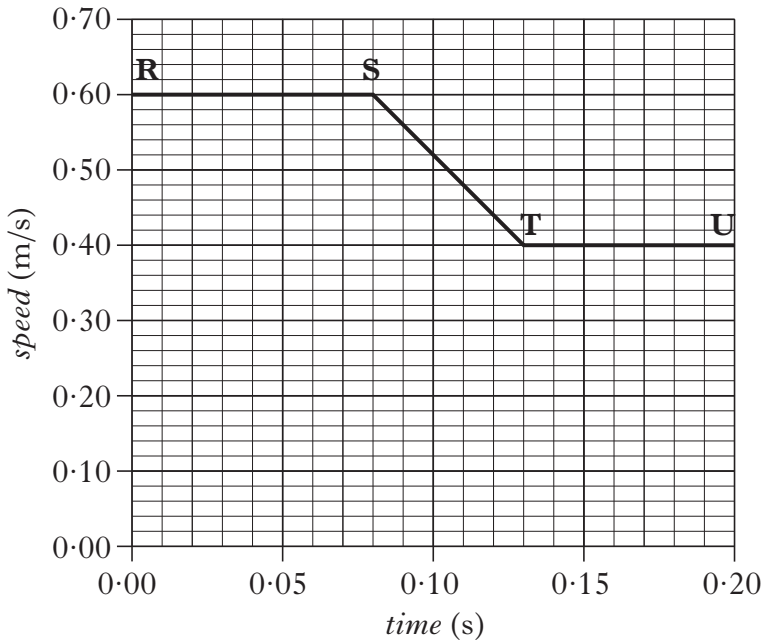
Vehicle Y is at rest before the collision.

Vehicle X is given a push and then released.

A pin on vehicle X sticks into a cork on vehicle Y causing them to join and move off together.

The motion sensor measures the speed of vehicle X every 0·01 s.

The graph shows the results obtained from the investigation after vehicle X has been released.



Marks

22. (continued)

(*a*) State the speed of ultrasonic waves in air. **1**

(*b*) (i) Describe the motion of vehicle X between points **S** and **T**. **1**

(ii) Calculate the distance travelled by vehicle X between points **S** and **T**. **2**

(iii) Vehicle X has a mass of 0·50 kg.

Use the law of conservation of momentum to show that vehicle Y has a mass of 0·25 kg. **2**

(iv) (A) Calculate the kinetic energy lost in this collision. **3**

(B) What happens to the lost kinetic energy? **1**

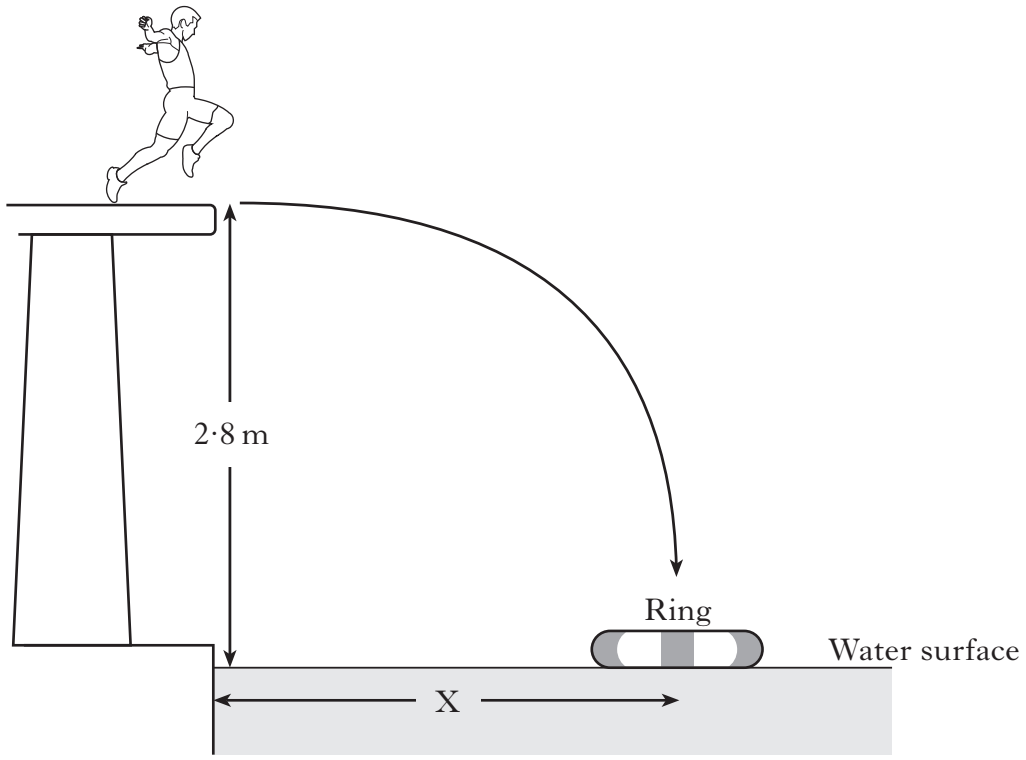
(10)

[Turn over

Marks

23. In a TV game show contestants are challenged to run off a horizontal platform and land in a rubber ring floating in a swimming pool.

The platform is 2·8 m above the water surface.



(*a*) A contestant has a mass of 60 kg.

He runs off the platform with a horizontal velocity of 2 m/s. He takes 0·75 s to reach the water surface in the centre of the ring.

(i) Calculate the horizontal distance X from the poolside to the centre of the ring. **2**

(ii) Calculate the vertical velocity of the contestant as he reaches the water surface. **2**

(*b*) Another contestant has a mass of 80 kg.

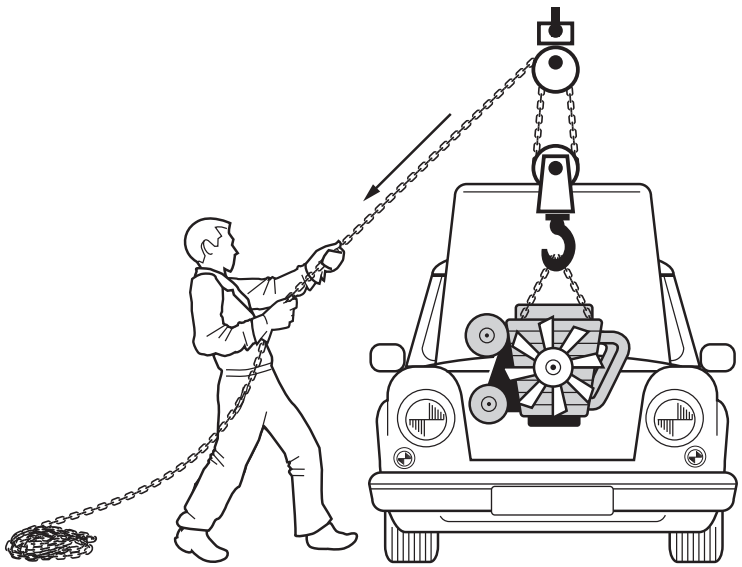
Will she need to run faster, slower or at the same horizontal speed as the first contestant to land in the ring?

You **must** explain your answer. **2**

(6)

Marks

24. In a garage, a mechanic lifts an engine from a car using a pulley system.



(*a*) The mechanic pulls 4·5 m of chain with a constant force of 250 N.
Calculate the work done by the mechanic. **2**

(*b*) The engine has a mass of 144 kg and is raised 0·75 m.
Calculate the gravitational potential energy gained by the engine. **2**

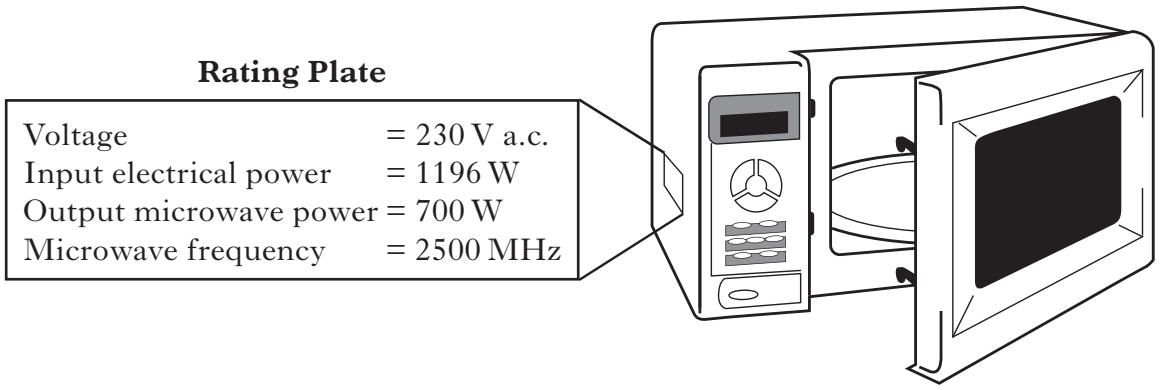
(*c*) Calculate the percentage efficiency of the pulley system. **2**

(6)

[Turn over

Marks

25. The rating plate on a microwave oven shows the following data.



(*a*) State what is meant by the term voltage. **1**

(*b*) (i) Calculate the input current. **2**

(ii) The microwave is used to heat a cup of milk for 1 minute 30 seconds. Calculate how much electrical charge passes through the flex in this time. **2**

(iii) The milk of mass 0·25 kg absorbs 48 kJ of energy during the heating process. The specific heat capacity of milk is 3900 J/kg °C.

Calculate the temperature rise in the milk. **2**

(*c*) Calculate the wavelength of the microwaves. **2**

(9)

[Turn over for Question 26 on *Page eighteen*

Marks

26. An overhead projector contains a lamp and a motor that operates a cooling fan.

A technician has a choice of two lamps to fit in the projector.

Lamp A: rated 24·0 V, 2·5 Ω

Lamp B: rated 24·0 V, 5·4 Ω

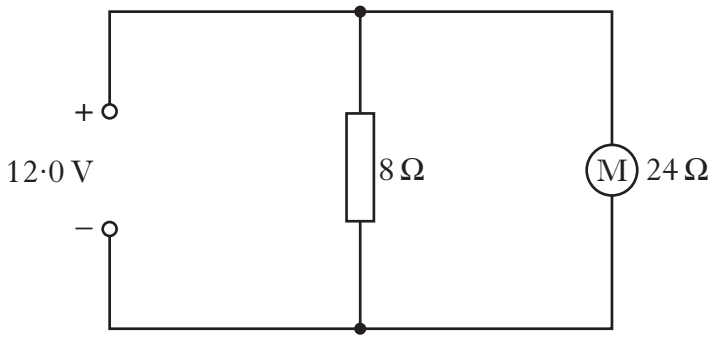
(*a*) Which lamp gives a brighter light when operating at the correct voltage? Explain your answer. **2**

(*b*) Calculate the power developed by lamp A when it is operating normally. **2**

(*c*) The overhead projector plug contains a fuse.

Draw the circuit symbol for a fuse. **1**

(*d*) The technician builds a test circuit containing a resistor and a motor, as shown in **Circuit 1**.



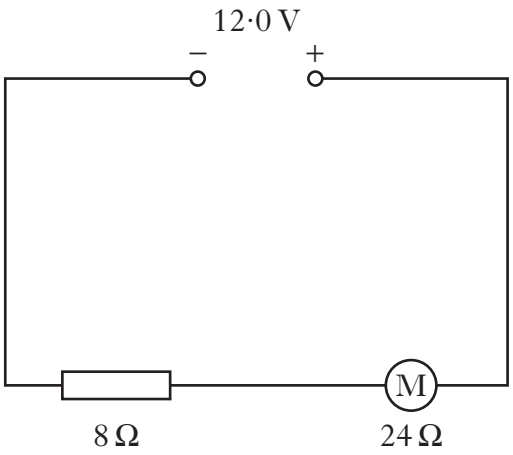
Circuit 1

(i) State the voltage across the motor. **1**

(ii) Calculate the combined resistance of the resistor and the motor. **2**

26. (continued)

(*e*) The resistor and the motor are now connected in series, as shown in **Circuit 2**.



Circuit 2

State how this affects the speed of the motor compared to **Circuit 1**.
Explain your answer. **2**

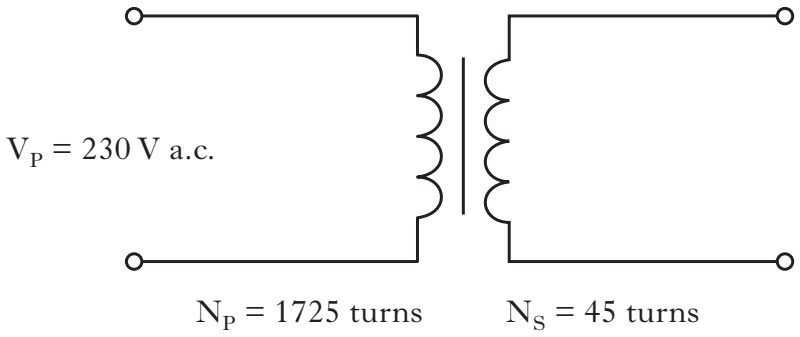
(10)

[Turn over

Marks

27. A mains operated mobile phone charger contains a transformer.

Part of the circuit is shown below.



The primary coil of the transformer has 1725 turns.

The secondary coil has 45 turns.

(*a*) Calculate the voltage across the secondary coil. **2**

(*b*) When the charger is connected to a mobile phone the output current is 0·80 A.
Calculate the current in the primary coil. **2**

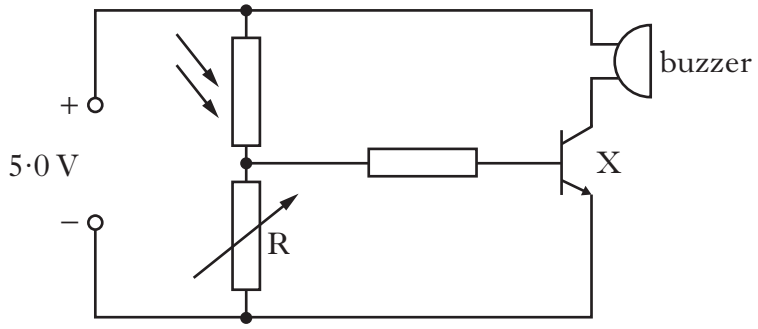
(*c*) What is the frequency of the mains supply in the UK? **1**

(*d*) 230 V a.c. is the quoted value of the mains supply in the UK.
State how the quoted value compares with the peak value. **1**

(6)

Marks

28. A photographic darkroom has a buzzer that sounds when the light level in the room is too high. The circuit diagram for the buzzer system is shown below.



(*a*) (i) Name component X. **1**

(ii) What is the purpose of component X in the circuit? **1**

(*b*) The darkroom door is opened and the light level increases.

Explain how the circuit operates to sound the buzzer. **3**

(*c*) The table shows how the resistance of the LDR varies with light level.

Light level (units)	*LDR Resistance* (Ω)
20	4500
50	3500
80	2500

The variable resistor has a resistance of 570 Ω.

The light level increases to 80 units.

Calculate the current in the LDR. **3**

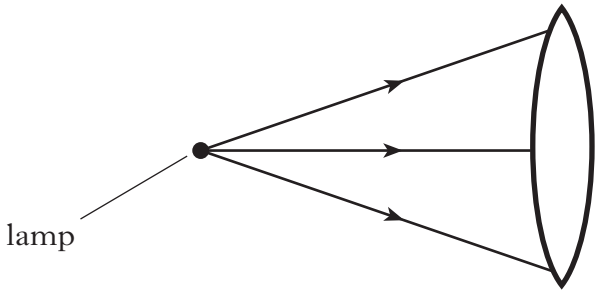
(*d*) What is the purpose of the variable resistor R in this circuit? **1**

(9)

[Turn over

Marks

29. A lighthouse uses a converging lens to produce a beam of light.



(*a*) The lamp is placed at the focal point of the lens.

Copy and complete the diagram to show the paths of the light rays after they pass through the lens. **1**

(*b*) The power of the lens is 6·25 D.

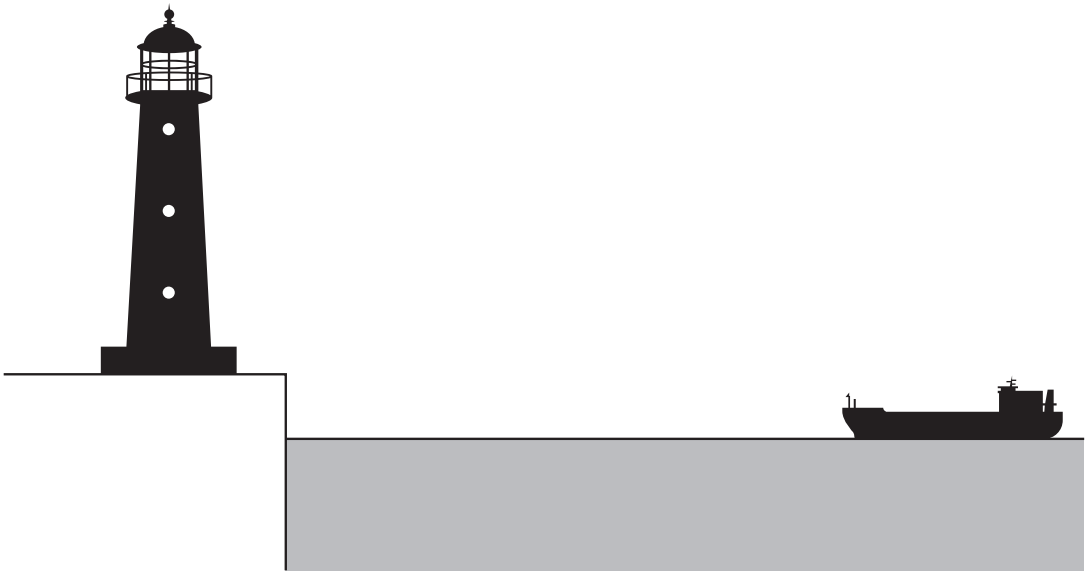
Calculate its focal length. **2**

(*c*) The lamp flashes once every 7·5 seconds.

What is the name given to the time between each flash? **1**

(*d*) The lighthouse also uses a foghorn to alert ships.

A ship is at a distance of 2·04 km from the lighthouse.



Calculate the time taken for the sound to reach the ship. **2**

(*e*) Light waves are transverse waves. Sound waves are longitudinal waves.

Describe each type of wave in terms of vibrations. **2**

(8)

Marks

30. A hospital radiographer calculates the equivalent dose of radiation absorbed by a patient. This is done by multiplying the absorbed dose by a radiation weighting factor.

(*a*) State what is meant by a radiation weighting factor. **1**

(*b*) During a scan of the patient's brain, the absorbed dose is measured as 1·5 mGy. The mass of the brain is 1·4 kg.

Calculate the energy absorbed by the brain during the scan. **2**

(*c*) In another medical procedure, a radioactive chemical is injected into a patient.

The chemical is prepared by the technician from a source which has an activity of 320 MBq.

The source has a half-life of 6 hours.

Calculate the activity of the source 18 hours later. **2**

(5)

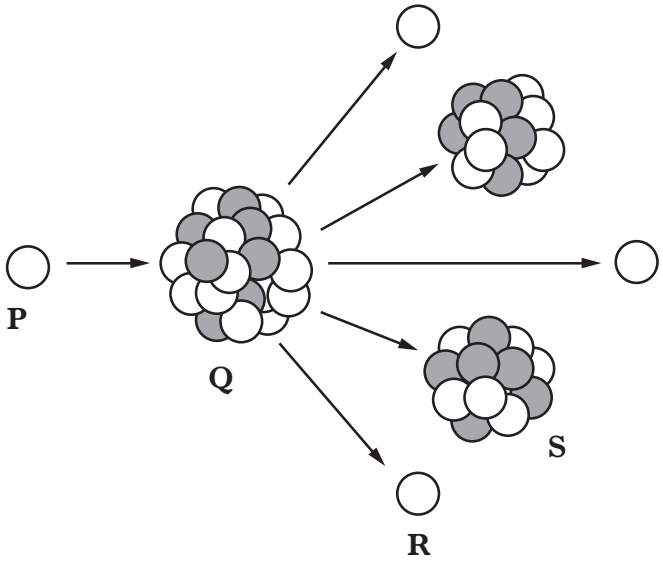
[Turn over

Marks

31. (*a*) A student is researching information on nuclear reactors.

The following diagram is found on a website.

It illustrates a type of reaction that takes place in a reactor.



(i) What type of nuclear reaction is shown in the diagram? **1**

(ii) The labels have been omitted at positions **P**, **Q**, **R** and **S** on the diagram.

State clearly what each of these labels should be. **2**

(*b*) Name the part of the reactor whose function is to prevent release of radiation beyond the reactor. **1**

(*c*) Disposal of some types of radioactive waste from nuclear reactors is particularly difficult.

Give a reason for this difficulty. **1**

(*d*) Electricity can be generated using fossil fuels or nuclear fuel.

State one advantage of using nuclear fuel. **1**

(6)

[*END OF QUESTION PAPER*]