LA SALLE COLLEGE

F6

F6 PHYSICS

Mock Examination 2019 to 2020

Paper I

Exam Number			

8:15 am – 10:45 am ($2\frac{1}{2}$ hours)

Section A

General Instructions

1. There are TWO sections, A and B, in this Paper. You are advised to finish Section A in about 60 minutes.
2. Section A consists of multiple-choice questions in this question paper, while Section B contains conventional questions printed separately in Question-Answer Book B.
3. Answers to Section A should be marked on the Multiple-choice Answer Sheet while answers to Section B should be written in the spaces provided in Question-Answer Book B. The Answer sheet for Section A and the Question-Answer Book for Section B will be collected separately at the end of the examination.
4. The diagrams in this paper are NOT necessarily drawn to scale.
5. The last two pages of the Question-Answer Book for Section B contain a list of data, formulae and relationships which you may find useful.

Instructions for Section A

1. Read carefully the instructions on the Answer Sheet. After the announcement of the start of the examination, you should first write you Exam Number on the cover page of the question paper and insert the information required in the spaces provided for "Subject", "Name", "Date" , "Level" , "Class" and "Exam No." (in the boxes for "Class No.") on the Answer Sheet.
2. When told to turn over the paper, check that all the questions are there. Look for the words '**END OF SECTION A'** after the last question.
3. All questions carry equal marks.
4. Answer all questions. Mark the answers of the Section A with an HB pencil on the Answer Sheet, so that wrong marks can be completely erased with a clean rubber. You must mark the answers clearly; otherwise you will lose marks if the answers cannot be captured.
5. You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.
6. No marks will be deducted for wrong answers.

There are 33 questions. Questions marked with "*" involve knowledge of the extension component.

Section A :

1. In USA, the Fahrenheit temperature scale is used. Conversion between Celsius temperature T_C and Fahrenheit temperature T_F (measured in °F) is $T_F = 1.8\,T_C + 32$. Which of the following is/are correct?

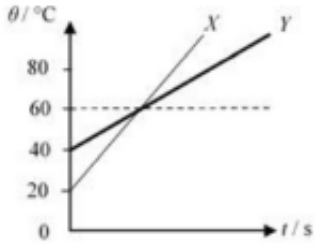
   (1) Ice melts at 0 °F. (2) Water boils at 212 °F.

   (3) An increase of 1 °C is the same as an increase of 1 °F.

   A. (2) only B. (3) only C. (2) & (3) only D. (1), (2) & (3)

2. Two objects X and Y are made of the same material. They are heated separately by heaters of the same power. The graph shows the variation of temperature θ of X and Y with time t. What is the ratio of mass of X to that of Y?

   A. 3:1 B. 2:1 C. 1:2 D. 1:3



3. Which of the following statements about the evaporation of a liquid must be correct?

   A. A liquid evaporates only when its temperature is higher than 0 °C.

   B. During evaporation, all molecules at the liquid surface gain enough potential energy to escape into the space above.

   C. Evaporation carries away the internal energy of the liquid.

   D. A liquid does not evaporate on a windless day.

4. Which of the following methods can keep ice for a longer time in a metal container?

   (1) Paint the wall of the container black.

   (2) Wrap the container with a layer of cotton.

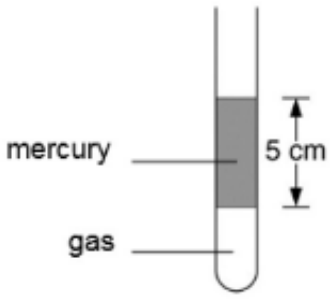
   (3) Put the container on a polystyrene tile.

   A. (1) & (2) only B. (1) & (3) only C. (2) & (3) only D. (1), (2) & (3)

5.* Some gas is sealed in a cylinder of cross-sectional area 2 cm^2 by a mercury column 5 cm long as shown. The cylinder is under atmospheric pressure of 100 kPa. The friction between the mercury column and the cylinder is negligible. Take the density of mercury as 13.4 g/cm^3. What is the pressure of the gas?

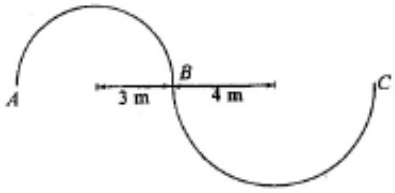
   A. 100 kPa B. 101 kPa C. 107 kPa

   D. Cannot be determined as the mass of the gas is not given



6. A student walks along a curve ABC, which is made up of two semi-circular parts AB and BC of radius 3 m and 4 m respectively. He takes 2 s to walk from A to B and 5 s to walk from B to C. Find the magnitude of the average velocity of the student from A to C.

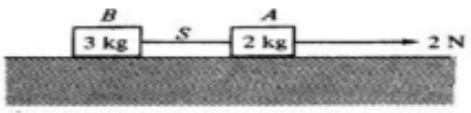
   A. 1.0 ms^{-1} B. 2.0 ms^{-1} C. 3.1 ms^{-1} D. 6.3 ms^{-1}



7. A stone falls freely from rest under gravity. If it travels a distance y in the 1st second, what is the distance it travels in the 2nd second?

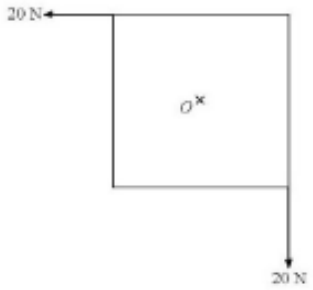
A. y B. $2y$ C. $3y$ D. $4y$

8. In the diagram shown, blocks A and B are connected by a light inextensible string and rest on a smooth horizontal table. The masses of A and B are 2 kg and 3 kg respectively. Block A is pulled by a force of 2 N. Find the tension in the string S.



A. 0.8 N B. 1.2 N C. 1.6 N D. 2.0 N

9. A square uniform board of weight 10 N is pivoted vertically at its centre O. The board is in equilibrium under the action of two forces, each of magnitude 20 N acting in the direction as shown. The total force acting on the pivot is



A. 0 N. B. 28 N. C. 36 N. D. 40 N.

10. The different in water temperature between the top and the bottom of a waterfall is 0.15 °C. Assuming no heat is lost from the water to the surroundings, what is the height of the waterfall? (The specific heat capacity of water is 4200 $Jkg^{-1}\,°C^{-1}$)

A. 46 m B. 64 m C. 360 m D. 630 m

11. A rocket of mass 5000 kg is at rest in space. It then explodes and breaks into two parts P_1 and P_2 of mass 2000 kg and 3000 kg respectively. Find the ratio of the kinetic energy of P_1 to that of P_2.

A. 4:9 B. 2:3 C. 3:2 D. 9:4

12. Two projectiles X and Y are launched simultaneously from the top of a building. X is launched horizontally with a speed of 2 ms^{-1} while Y is launched at an angle of 60° to the horizontal with a speed of 4 ms^{-1}. Which of the following statements are correct? Neglect air resistance.

(1) X and Y have the same velocity change over the same period of time.

(2) X and Y travel the same horizontal distances in the same period of time.

(3) X and Y never meet during their flights.

A. (1) & (2) only B. (1) & (3) only C. (2) & (3) only D. (1), (2) & (3)

13.* A car is travelling round a circular path with a constant speed v. The centripetal force acting on the car is F. Which of the following is INCORRECT?

A. F points towards the centre of the circular path.

B. The velocity of the car is perpendicular to its centripetal acceleration.

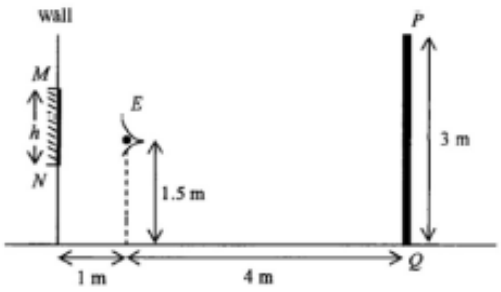
C. F is provided by the car's tyres.

D. $v = \frac{2\pi r}{T}$, where r is radius of the circular path and T is the period.

14* Jupiter's diameter is 1.40×10^8 m and the acceleration due to gravity on its surface is 24.8 ms^{-2}. Estimate the mass of Jupiter.

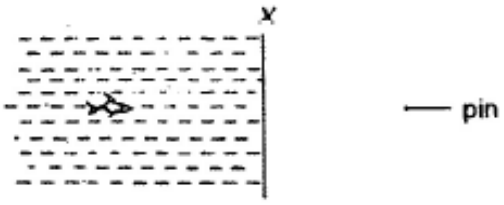
A. 2.60×10^{19} kg B. 5.20×10^{19} kg C. 1.82×10^{27} kg D. 7.29×10^{27} kg

15. In the figure shown, a plane mirror MN of height h is mounted in an adjustable vertical position on a vertical wall. E is an observer's eye which is 1 m from the wall and 1.5 m above the ground. PQ is a vertical post of height 3 m and is 4 m behind the observer. Looking into the mirror the observer can see the whole image of the post. What is the minimum value of h?



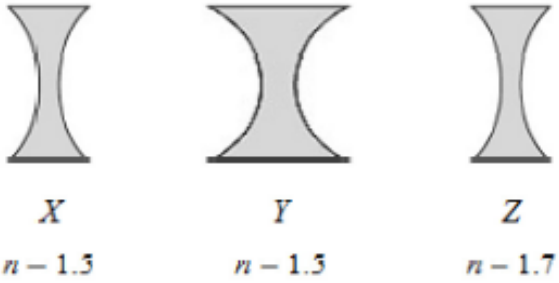
A. 0.25 m B. 0.30 m C. 0.50 m D. 0.60 m

16. A fish in a tank of water looks through a thin glass wall X at a pin. The image of the pin observed by the fish will be



A. longer than it actually is and nearer to X.
B. longer than it actually is and further away from X.
C. shorter than it actually is and nearer to X.
D. shorter than it actually is and further away from X.

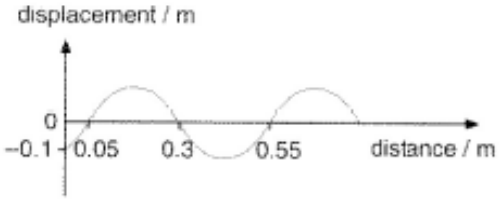
17. In the diagram shown, lenses X and Y are made of the same material but have different shapes, while lenses X and Z are made of different materials with different refractive index n but have the same shape. Which of the following statements are correct?



(1) X, Y and Z are diverging lenses.
(2) Y has a shorter focal length than X.
(3) Z has a shorter focal length than X.

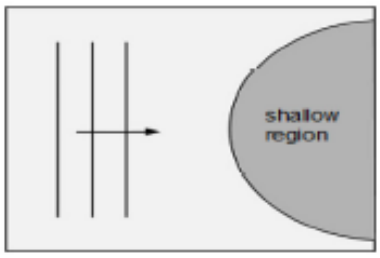
A. (1) & (2) only B. (1) & (3) only C. (2) & (3) only D. (1), (2) & (3)

18. The displacement-distance graph of a wave at a certain instant is shown. If the wave travels at 20 ms^{-1}, what is its period?



A. 0.025 s B. 0.3 s
C. 0.5 s D. 0.55 s

19. In a ripple experiment, a water wave travels towards a shallow region. Which of the following quantities of the wave would change after the wave enters the shallow region?



(1) Wavelength
(2) Speed
(3) Frequency

A. (1) & (2) only B. (1) & (3) only C. (2) & (3) only D. (1), (2) & (3)

20. Which of the following statements about electromagnetic waves are correct?

(1) The speeds of electromagnetic waves are equal to the speed of light in vacuum.

(2) All kinds of electromagnetic waves can travel in a vacuum.

(3) Electromagnetic waves are longitudinal waves.

A. (1) & (2) only B. (1) & (3) only C. (2) & (3) only D. (1), (2) & (3)

21. Which of the following statements about a longitudinal wave are correct?

(1) The particles at the centre of compressions are moving at the highest speed.

(2) Wavelength is the distance between two consecutive centres of rarefaction.

(3) All particles in the wave are moving in the same direction.

A. (1) & (2) only B. (1) & (3) only C. (2) & (3) only D. (1), (2) & (3)

22. Which of the following about ultrasound are correct?

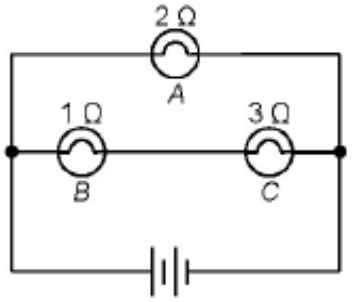
(1) The frequency of ultrasound is above 20 000 Hz.

(2) All animals including human beings cannot hear ultrasound.

(3) Ultrasound is commonly used in scanning of the foetus.

A. (1) & (2) only B. (1) & (3) only C. (2) & (3) only D. (1), (2) & (3)

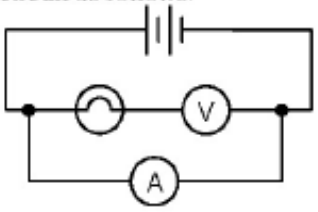
23. In the following circuit, light bulbs *A*, *B* and *C* respectively have resistance 2 Ω, 1 Ω and 3 Ω.



Which light bulb glows with the highest power?

A. Light bulb *A* B. Light bulb *B* C. Light bulb *C* D. Cannot be determined

24. A student mistakenly connects a circuit as follows.



Which of the following will happen?

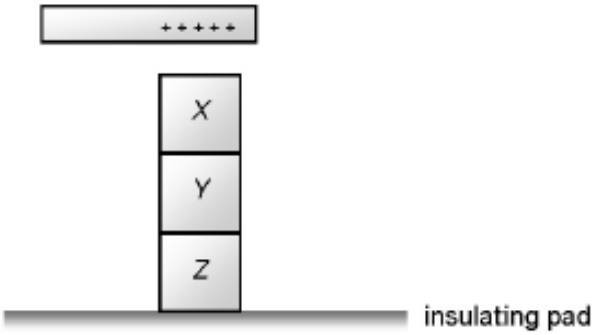
(1) The light bulb will be very dim.

(2) The voltmeter will show a near-zero reading.

(3) The ammeter will show a very large reading.

A. (1) & (2) only B. (1) & (3) only C. (2) & (3) only D. (1), (2) & (3)

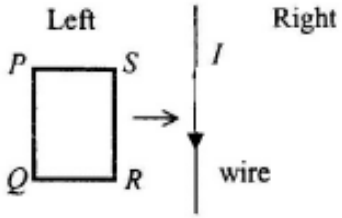
25. Three uncharged metal boxes X, Y and Z are placed as shown. A positively charged rod is brought near X and held fixed there.



If X is earthed momentarily, which of the following correctly describes the charges of X, Y and Z?

	X	Y	Z
A.	negative	zero	positive
B.	negative	zero	zero
C.	negative	negative	negative
D.	zero	zero	zero

26.* The figure shows a rectangular coil $PQRS$ moving from left to right with a uniform speed across an insulated metal wire in the plane of the coil. The wire carries a steady current I. Which of the following gives the correct sequence for the direction of the current induced in the coil $PQRS$?



A. Clockwise and then anticlockwise
B. Anticlockwise and then clockwise
C. Clockwise, then anticlockwise and finally clockwise again
D. Anticlockwise, then clockwise and finally anticlockwise again

27.* An alternating current passing through a resistor varies sinusoidally as shown in Figure (a). The average power dissipated by the resistor is $4W$. If another alternating current with waveform in Figure (b) is used instead, what will be the average power dissipated by the resistor?

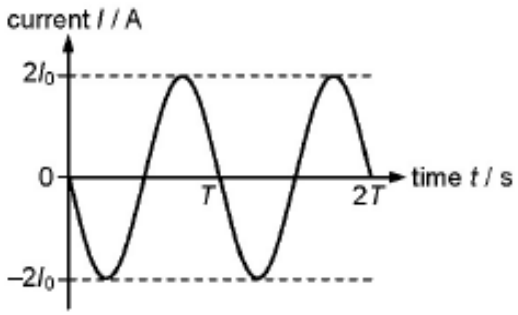


Figure (a)

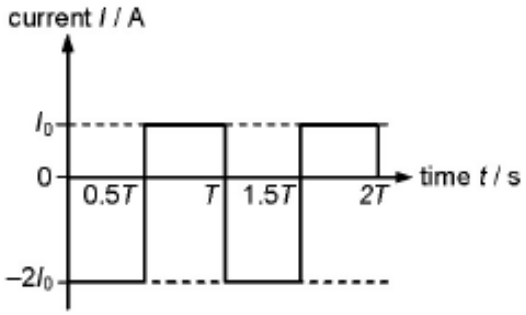
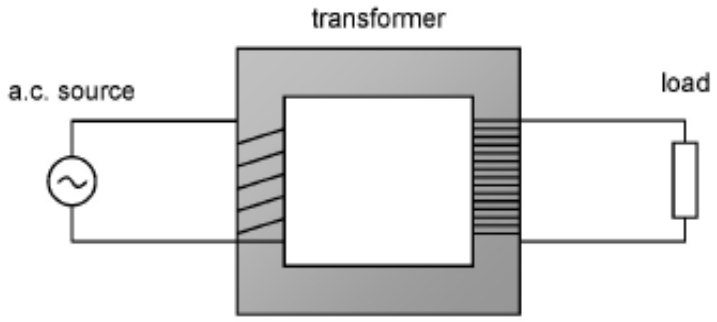


Figure (b)

A. $\frac{W}{\sqrt{2}}$ B. 1.25 W C. 2.5 W D. 5 W

28.* The following figure shows an ideal transformer, in which the primary and secondary coils have respectively 50 and 500 turns. The r.m.s. voltage of the a.c. source is 220 V and the resistance of the load is 100 Ω.



Find the peak current in the secondary circuit.

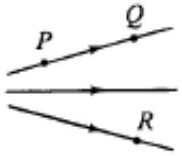
A. $11\sqrt{2}$ A B. 22 A C. $22\sqrt{2}$ A D. 44 A

29. A charged particle is accelerated across the gap between two parallel metal plates maintained at a certain potential difference in a vacuum. Assuming there is no gravitational force, the energy acquired by the charged particle in crossing the gap depends on

(1) the potential difference between the plates.
(2) the width of the gap.
(3) the mass of the charged particle.

A. (1) only B. (3) only C. (1) & (2) only D. (2) & (3) only

30. The straight lines in the diagram represent electric field lines. Which of the following statements about this electric field are correct?



(1) A stationary negative charge placed at P tends to move to Q.
(2) The electric field strength at P is stronger than that at Q.
(3) Work has to be done in moving a positive charge from R to P.

A. (1) & (2) only B. (1) & (3) only C. (2) & (3) only D. (1), (2) & (3)

31. The decay constant of a radioactive sample is 3×10^{-4} s^{-1}. The sample initially consists of 80% of undecayed nuclides. How long does it take for the percentage of the undecayed nuclides in the sample to decrease to 2%?

A. 0.21 hours B. 3.42 hours C. 3.62 hours D. 6.19 hours

32. A decay series is shown below. The series ends with nuclide T.

$$P \xrightarrow{\alpha} Q \xrightarrow{\beta} R \xrightarrow{\gamma} S \xrightarrow{?} T$$

It is known that P and T are isotopes. Which of the following statements are correct?

(1) R and S have the same number of protons and neutrons.
(2) Some nuclides in this decay series are unstable.
(3) S emits a neutron to form T.

A. (1) & (2) only B. (1) & (3) only C. (2) & (3) only D. (1), (2) & (3)

33.* When a polonium-210 (Po-210) nucleus undergoes α decay, 5.31 MeV of energy is released. The half-life of Po-210 is 138 days. Estimate the total amount of energy released by 1 kg of Po-210 in 64 days. Take the mass of a Po-210 atom as 210 u.
Given: 1 u = 1.661×10^{-27} kg = 931 MeV

A. 4.19×10^{24} MeV B. 4.46×10^{24} MeV C. 7.61×10^{24} MeV D. 1.52×10^{25} MeV

*** End of Section A ***

LA SALLE COLLEGE

F6

F6 PHYSICS

Mock Examination 2019 to 2020

Paper I

Section B: Question-Answer Book B

8:15 am – 10:45 am ($2\frac{1}{2}$ hours)

This paper must be answered in English

Exam Number | | | |

Instructions for Section B

1. Write your Exam Number in the spaces provided on this cover page and on the top of every odd numbered page.
2. Refer to the general instruction on the cover page of the Question Paper of Section A.
3. Answer ALL questions. Write your answers in the spaces provided in this Question-Answer Book.
4. Graph paper and supplementary answer sheets will be provided on request. Write your Examination Number on each sheet and attach them in this Question-Answer Book.
5. Unless otherwise specified, numerical answers should be either exact or correct to 3 significant figures.

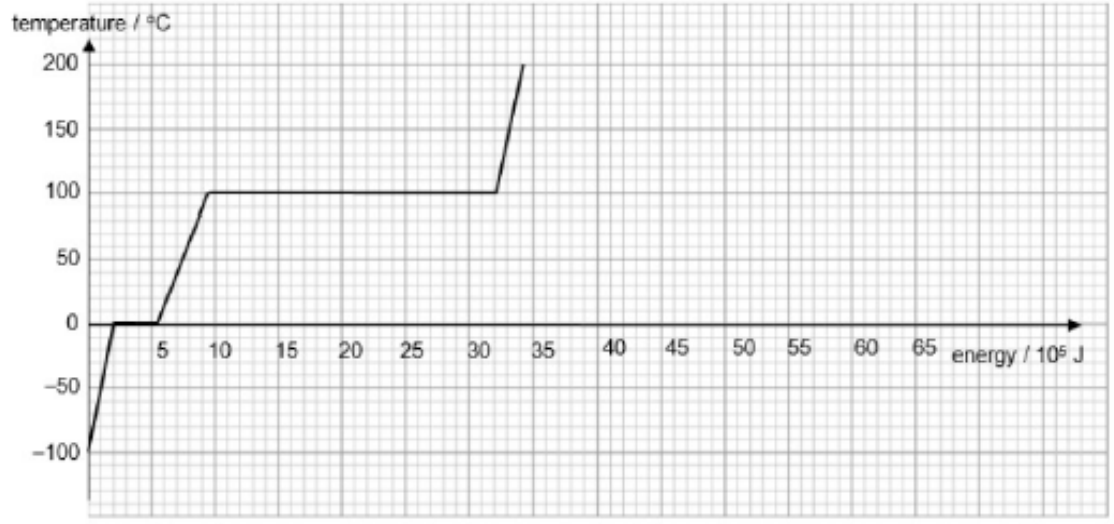
	Marker's Use only
Section B Question No.	**Marks**
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Total	

Answer ALL questions in this section. Parts marked with "*" involve knowledge of the extension component. Write your answers in the spaces provided.

Question No.	1	2	3	4	5	6	7	8	9	10
Marks	8	8	8	8	8	8	8	7	11	10

1. Ice of mass 0.95 kg is heated by a 1600 W heater from -100 °C to 200 °C. The graph below shows how its temperature changes with the energy transferred to it.



(a) Use the graph to estimate

(i) the specific heat capacity of ice. (2 marks)

(ii) the specific latent heat of vaporisation of water. (2 marks)

(b) How long does it take to melt the ice into steam? (2 marks)

(c) Suppose the mass of the ice is doubled and it is heated at the same rate. Sketch on the same temperature-energy graph of the ice above when it is heated from -100 °C to 200 °C. (2 marks)

Exam Number			

2. A frictionless gas-filled cylinder is fitted with a movable piston with area of 0.4 m^2 as shown in Figure 2. An ideal gas at a temperature of 27 °C and a pressure of 1.3×10^5 Pa is filled in it. Assuming that the pressure outside the cylinder is 1.0×10^5 Pa.

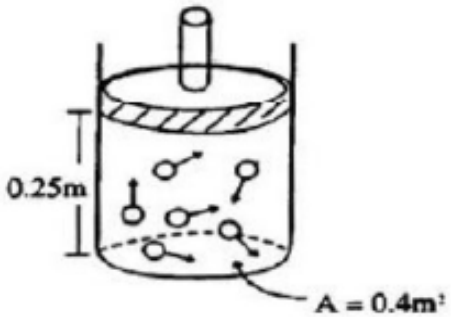


Figure 2

(a) How many moles of gas are filled in the cylinder? (2 marks)

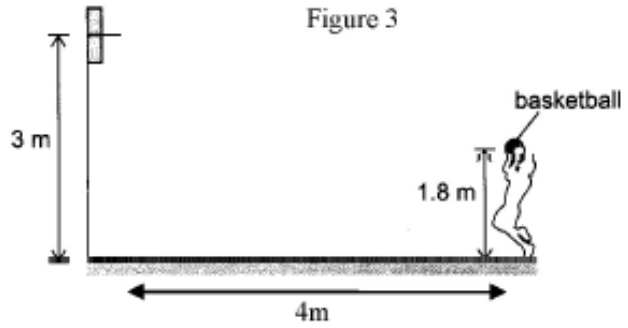
(b) If the piston is in equilibrium with the gas, find the mass of the piston. (3 marks)

(c) The gas is compressed isothermally to half of its original volume. Find the gas pressure after this compression. (2 marks)

(d) Apart from high temperatures, State the other condition that a real gas will behave like an ideal gas. (1 mark)

3. In a basketball match, Henry shoots the basketball at the ring of the basketball board 4 m away from him as shown in Figure 3. The height of the ring is 3 m and the basketball is 1.8 m above the ground just before Henry shoot it.

Figure 3



If the basketball hits the ring of the basketball board at its highest point of trajectory and the air resistance and the size of the basketball are negligible, find

(a) the time of flight before the basketball hits the ring of the basketball board, (3 marks)

(b) the speed of the basketball just after it leaves Henry's hand, and (3 marks)

(c) the angle of projection of Henry's shooting. (2 marks)

Exam Number			

4. A uniform rod of mass 16 kg and length 2 m is pivoted at point A on the ground and held stationary with a force F acting at point B as shown in Figure 4. The force F is pointing in a direction which is 60° from the ground.

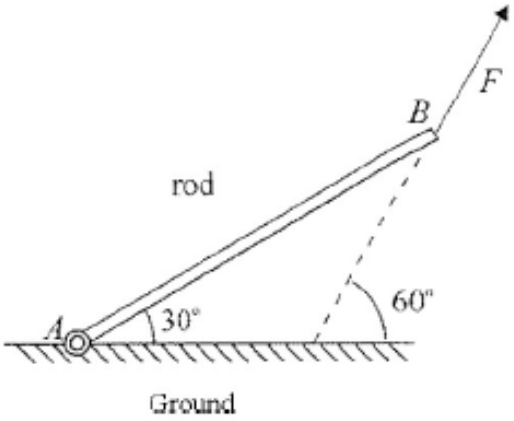


Figure 4

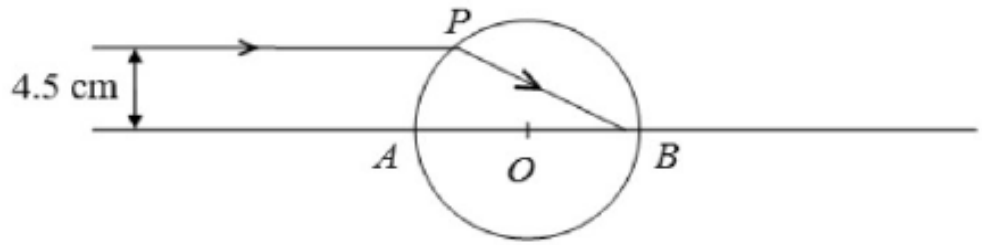
(a) Draw on the space beside the above figure the free body diagram of the uniform rod. (2 marks)

(b) (i) What is the magnitude of the force F? (2 marks)

(ii) Find the magnitude and direction of the resultant force acting on the uniform rod by the ground at point A. (4 marks)

5. A monochromatic light ray enters a glass sphere of diameter 10.0 cm from air as shown in Figure 5. The incident ray is parallel to the diameter AOB with a separation of 4.5 cm. After entering the glass sphere, the ray crosses the diameter AOB at a certain point between centre O and point B.

Figure 5



(a) Mark on Figure 5 the angle of incidence i and angle of refraction r. (1 mark)

(b) Calculate the angle of incidence i. (2 marks)

(c) If the angle of refraction is 28.6°, calculate the refractive index of the glass sphere. (2 marks)

(d) If the frequency of the light ray is 5.4×10^{14} Hz, find its wavelength, in nm, inside the glass sphere. (3 marks)

Exam Number			

6. Figure 6 is a simple experimental setup to study the image formed by a convex lens. The translucent ruler is an illuminated object, the position of which remains unchanged throughout the experiment. The position of the lens is adjusted so that a sharp image of the ruler is formed on the screen.

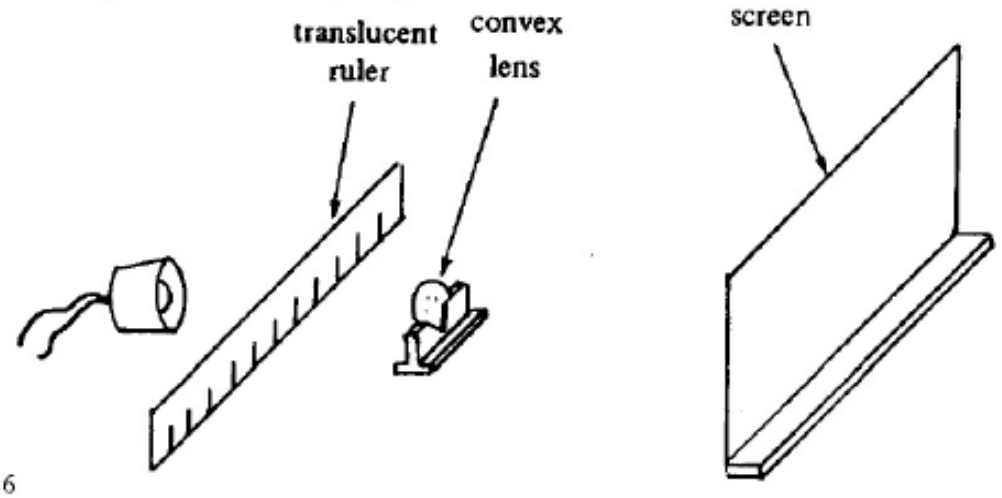


Figure 6

(a) Suppose that the distance between the lens and the ruler is 25 cm and the focal length of the lens is 20 cm. What is the distance between the ruler and the screen? (3 marks)

(b) If the screen is now moved a few centimetres towards the ruler, how would you adjust the position of the lens to give a sharp image on the screen again? (1 mark)

(c) Keeping the lens position unchanged, it is now replaced by another convex lens of shorter focal length, and the screen is adjusted to give a sharp image. How would the magnification of the image be affected? Increase, remain unchanged or decrease? Explain your answer briefly. (3 marks)

Magnification: _____

Explanation: _____

(d) Explain the reason why an image will not be formed on the screen when the distance between the lens and the ruler is smaller than the focal length of the lens. (1 mark)

7. An earthquake propagates in the form of waves. The quake centre produces both longitudinal and transverse waves, which are known as *P* waves and *S* waves respectively. The two types of wave propagate at different speeds in the earth's crust. Figure 7.1 shows the distance-time graphs for these two waves.

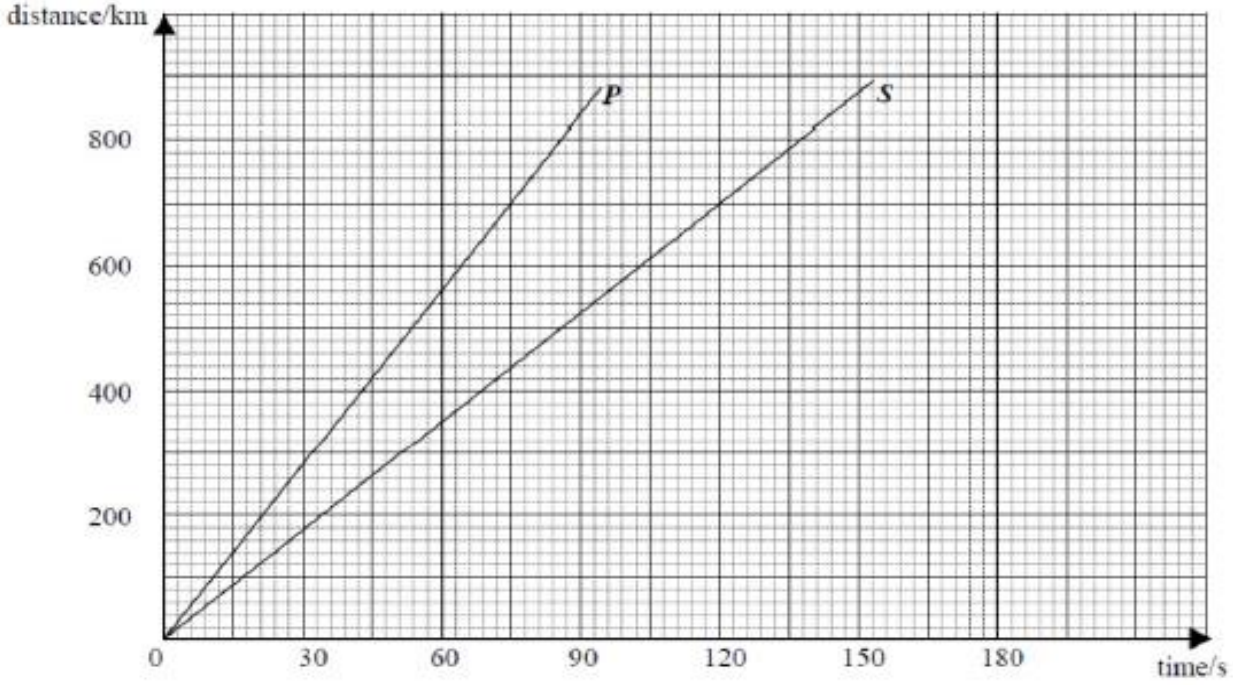


Figure 7.1

Three detecting stations *A*, *B* and *C* are located at the vertices of an equilateral triangle as shown in Figure 7.2. Their mutual separation is 600 km. Figure 7.3 shows the records (seismograph traces) of an earthquake recorded by these stations. Due to the difference in speeds, the *P* and *S* waves are detected at different times. Such a time difference is called the *S*-*P* interval. The *S*-*P* intervals are respectively 45 s, 27 s and 18 s for stations *A*, *B* and *C*.

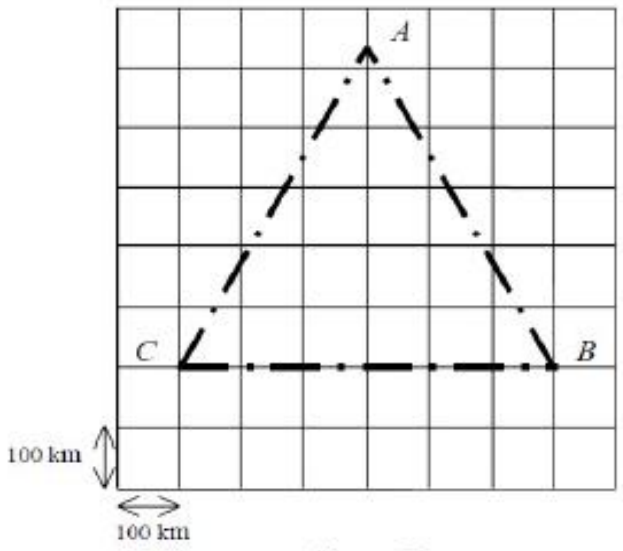


Figure 7.2

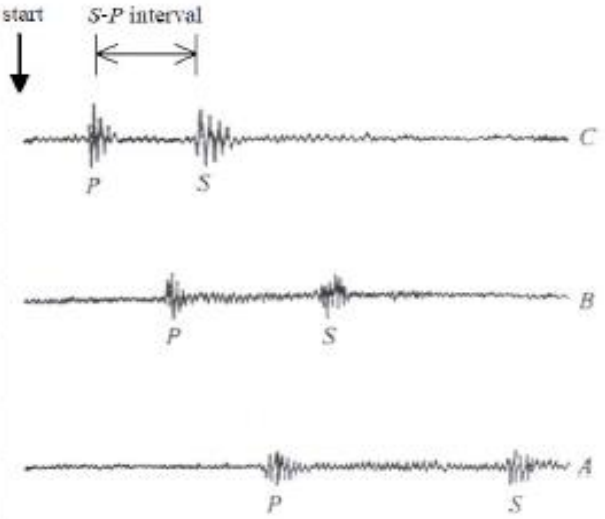


Figure 7.3

Exam Number			

(a) With reference to the vibrations of particles, state the difference between longitudinal and transverse waves. (1 mark)

(b) Which station *A*, *B* and *C*, is the closest to the quake centre? Give THREE reasons to support your answer. (4 marks)

Station:

Reason 1:

Reason 2:

Reason 3:

(c) (i) Use Figure 7.1 to find the distance of station *A* from the quake centre. Indicate clearly your answer in Figure 7.1. (2 marks)

Distance of station *A* from the quake centre:

(ii) Hence, use symbol "X" to indicate the approximate location of the quake centre in Figure 7.2. (1 mark)

------ Blank Space -----

8. An apparatus is set up in Figure 8a to measure current. Coil X is a 100 turns circular coil of mean diameter 300 mm. Square coil Y of area 3 mm^2 and 100 turns, is pivoted at the centre of coil X and is free to turn about a horizontal axis AA', in the plane of coil X. When there is no current, the 40 mg rider is adjusted to make the pointer horizontal.

Given: the magnetic field B produced by current I at the centre of coil X is $B = \frac{N\mu_0 I}{2R}$

where N is the number of turns, μ_0 is the permeability of free space, I is the current and R is the radius.

Figure 8a

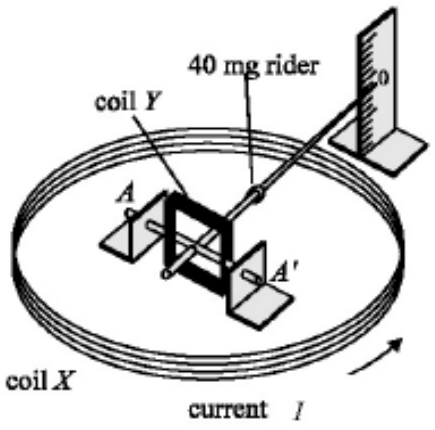
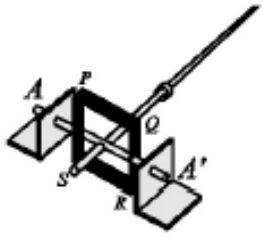


Figure 8b



(a) Find the magnetic field produced by the current in the coil X at its centre, express the answer in terms of the current I. (1 mark)

(b) If the coils X and Y are connected in series. When an current I flows through the two coils, the rider of mass 40 mg has to be moved 80 mm to the right to restore the pointer to a horizontal position.

(i) In Figure 8b, which direction should the current in coil Y be flowing, along $PQRS$ or $PSRQ$? (1 mark)

(ii) What will be the torque acting on the square coil Y when an current I flows through the two coils? (2 marks)

(iii) Find the current I in the circuit. (3 marks)

Exam Number			

9. As shown in Figure 9, a conducting rod of length l = 0.5 m is placed on two parallel conducting rails which are connected with a resistor R = 40 Ω. A uniform magnetic field B = 20 mT exists and suppose the rod is initially at a distance s from the resistor and it is kept moving at constant velocity $v = 1\,\text{ms}^{-1}$.

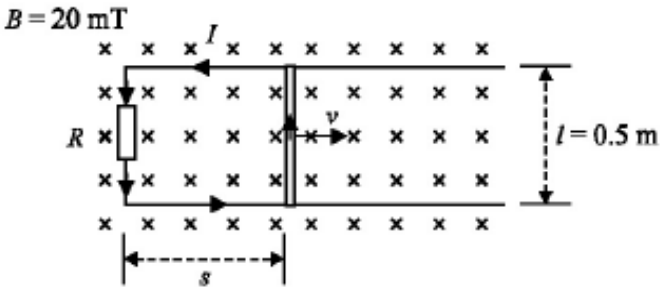


Figure 9

(a) Find a general expression of the induced e.m.f. ε, in terms of B, s, v, l *or* R, in the circuit and determine the magnitude of the e.m.f ε. (4 marks)

(b) What will be the power dissipation of the induced current flowing in the resistor? (3 marks)

(c) Briefly describe the change of the energy of the system. (2 marks)

(d) Find the magnitude of the external force required to keep the conducting rod moving at constant velocity v = 1 ms^{-1}. (2 marks)

10. Nuclear fusion power is regarded as a clean sustainable energy source for the future. One possible fusion reaction to be used in a fusion reactor is shown below.

$$^{2}_{1}\mathrm{H} + ^{3}_{1}\mathrm{H} \rightarrow ^{4}_{2}\mathrm{He} + ^{1}_{0}\mathrm{n} + \text{energy}$$

(a) Using the following data, calculate the energy released in the fusion in joules.

nuclide	mass (u)
neutron	1.008 665
hydrogen-2	2.014 102
hydrogen-3	3.016 049
helium-4	4.002 603

(Given: 1 u = 1.661×10^{-27} kg and $c = 2.998 \times 10^{8}$ m s^{-1}) (2 marks)

(b) A major difficulty of harnessing nuclear fusion power is the high initiating temperature arising from the electrostatic repulsion between the positively charged nuclei in the fusion reaction. Hydrogen nuclei must be less than 1×10^{-14} m apart in order to start the fusion reaction. Suppose the electric potential energy of two hydrogen nuclei at this separation is 2.30×10^{-14} J.

(i) In a fusion reaction, to overcome the electrostatic repulsion between hydrogen nuclei and bring them close enough for a head-on collision, kinetic energy must be provided to each nucleus. Estimate the temperature at which the average kinetic energy of a hydrogen nucleus is required. Assume the reactants to be a monatomic ideal gas. (3 marks)

(ii) In fact, nuclear fusion can occur at a temperature about 10 times lower than that in (i). Suggest one reason for this. (2 marks)

(c) Some experimental fusion reactors use magnetic field to confine the fuel. Briefly explain why such confinement is needed. (1 mark)

(d) Why is nuclear fusion power described as 'clean'? Compare the products of nuclear fusion with that of combustion of fossil fuels. (2 marks)

LA SALLE COLLEGE

F6

F6 PHYSICS

Mock Examination 2019 to 2020

Paper II

Question-Answer Book

11:15 am – 12:15 pm (1 hour)

This paper must be answered in English

Exam Number			

Instructions

1. Write your Exam Number in the spaces provided on this cover page and on the top of every odd numbered page.
2. This paper consists of TWO sections, Sections A and B. Each section contains eight multiple-choice questions and one structured question which carries 10 marks. Attempt All questions.
3. Answer ALL questions. For multiple-choice questions, blacken the appropriate circle with an HB pencil. Choose the **BEST** answer from the four options. You should mark only ONE answer for each question. If you mark more than one answer, you will receive NO MARKS for that question. For Structured Questions, write your answers in the Answer Book.
4. Graph paper and supplementary answer sheets will be provided on request. Write your Examination Number on each sheet and attach them inside this Question-Answer Book.
5. The diagrams in this paper are NOT necessarily drawn to scale.
6. Unless otherwise specified, numerical answers should be either exact or correct to 3 significant figures.
7. The last two pages of this question paper contain a list of data, formulae and relationships which you may find useful.

	Marker's Use only
Section A	**Marks**
MC Questions	
Structured Question	
Section B	**Marks**
MC Questions	
Structured Question	

Total	

Section A: Atomic World

Q.1 Multiple-choice questions

1.1 When an α particle is directed towards a gold atom, it bounces back. Which of the following is suggested by this result?

(1) The mass of the α particle is about the same as the gold atom.

(2) The α particle experiences a repulsive force.

(3) All the charged particles in the gold atom are concentrated in a tiny core.

A. (1) only

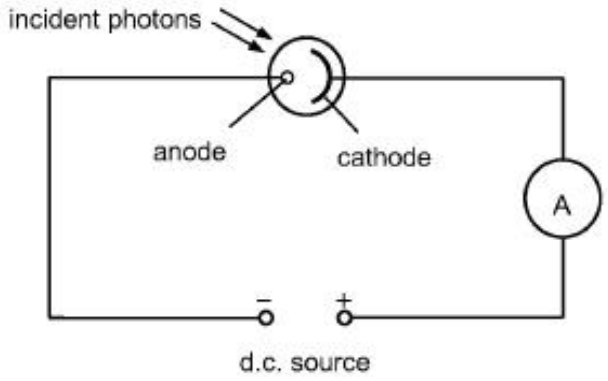
B. (2) only

C. (2) and (3) only

D. (1), (2) and (3)

A	B	C	D
○	○	○	○

1.2 A photocell is connected to a d.c. source with constant e.m.f. The polarities are connected as shown.



When photons each of energy 4 eV are incident on the cathode of the photocell, the maximum kinetic energy of the photoelectrons reaching the anode is 2 eV. Which of the following **MUST BE** correct?

A. If photons each of energy 2 eV are incident on the cathode, no photoelectron is emitted.

B. If photons each of energy 2 eV are incident on the cathode, photoelectrons are emitted but none of them reach the anode.

C. If photons each of energy 2 eV are incident on the cathode, photoelectrons are emitted and the maximum kinetic energy of the photoelectrons reaching the anode is 1 eV.

D. The work function of the cathode is 2 eV.

A	B	C	D
○	○	○	○

Exam Number			

1.3 According to Bohr's model, the electron in a hydrogen atom

A. emits energy when it stays in a certain orbit.

B. emits energy when it moves from a larger orbit to a smaller orbit.

C. can move to the ground state by emitting the ionization energy.

D. can escape from the atom by emitting high enough energy.

A	B	C	D
○	○	○	○

1.4 A hydrogen atom absorbs a photon of energy E so that it is excited from quantum number $n = 2$ to $n = 3$. How much energy would it absorb if it is excited from quantum number $n = 3$ to $n = 4$?

A. $\frac{7}{144}E$

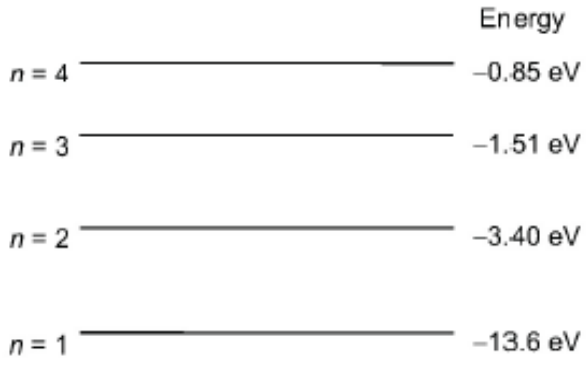
B. $\frac{3}{16}E$

C. $\frac{7}{20}E$

D. $\frac{1}{2}E$

A	B	C	D
○	○	○	○

1.5 Several energy levels of a hydrogen atom are shown in the figure below.



Which of the following photons can be absorbed by a hydrogen atom in its ground state?

A. A photon with energy 1.51 eV

B. A photon with energy 2.55 eV

C. A photon with energy 12.3 eV

D. A photon with energy 14.5 eV

A	B	C	D
○	○	○	○

1.6 A hydrogen atom is raised to the 4th excited state. Which of the following wavelengths of visible light must **NOT** be emitted when the atom returns to the ground state?

A. 435 nm
B. 488 nm
C. 605 nm
D. 658 nm

A	B	C	D
○	○	○	○

1.7 Which of the following statements about a scanning tunnelling microscope are correct?

(1) It only works on a conducting surface.
(2) It makes use of quantum tunnelling to produce images of a sample surface.
(3) It has a high resolving power because the electrons in the current produced in it have very short wavelengths.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A	B	C	D
○	○	○	○

1.8 Which of the following are the functions of adding titanium dioxide (TiO_2) nano particles to fabrics?

(1) Blocking UV light
(2) Preventing the static charges to accumulate
(3) Inhibiting the growth of bacteria

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A	B	C	D
○	○	○	○

Exam Number			

Q.1 Structured Question

1.9 A photocell is connected to a variable power supply. A micro-ammeter is also connected in the circuit to measure the photoelectric current. The metal plate in the photocell is illuminated by blue light. The intensity of the light is 0.04 W m^{-2} and the wavelength is 480 nm. The graph below shows how the photoelectric current I varies with the potential difference V across the photocell.

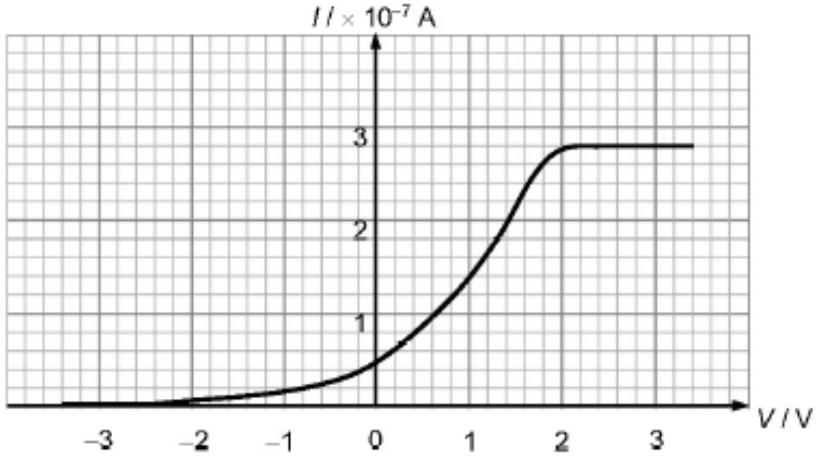


Figure 1.1

(a) Estimate the number of photoelectrons emitted by the metal plate per second. (2 marks)

(b) The area of the metal plate receiving the blue light is 1×10^{-4} m^2. Estimate the number of photons hitting the metal plate per second. (3 marks)

(c) Give ONE reason for the difference between the numbers in (a) and (b). (1 mark)

(d) Compare the kinetic energy of a photoelectron just being emitted and the energy of the photon it absorbs. Explain your answer without calculation. (2 marks)

(e) Violet light is then used to replace blue light. Suppose that the number of photons hitting the metal plate per second remains the same. Use a dotted line to sketch the corresponding curve in Figure 1.1. (2 marks)

***** End of Section A *****

Section B: Energy and Use of Energy

Q.2 Multiple-choice questions

2.1 Two light bulbs have the same power output but different brightness. Which of the following is/are the possible reason(s)?

(1) The intensities of visible light given out by the two bulbs do not peak at the same wavelength.

(2) The two bulbs have different power input.

(3) The two bulbs emit infra-red and ultra-violet radiations in addition to visible light.

A. (1) only

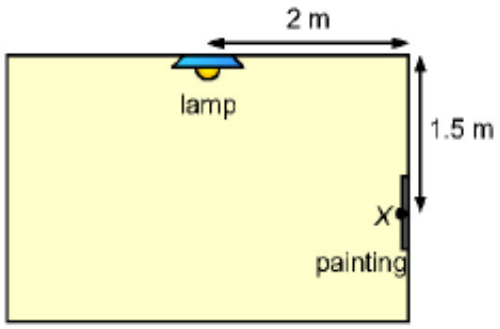
B. (1) and (3) only

C. (2) and (3) only

D. (1), (2) and (3)

A	B	C	D
○	○	○	○

2.2 A painting is fixed on a wall. X is a point on the painting and is 1.5 m below the ceiling, as shown in the following figure. A lamp of luminous flux 1500 lm is placed at a distance 2 m from the wall.



Estimate the illuminance at X. Take the lamp as a point source, and neglect any reflections of the walls and the ceiling.

A. 15.3 lx

B. 19.1 lx

C. 192 lx

D. 240 lx

A	B	C	D
○	○	○	○

2.3 An air conditioner operates at 1500 W and removes 2.0×10^5 J of heat from a room in 1 minute. Find the coefficient of performance of the air conditioner.

A. 0.45

B. 0.55

C. 1.22

D. 2.22

A	B	C	D
○	○	○	○

Exam Number			

2.4 A solar cell is connected to an electric motor. Which of the following would happen if sunlight falls onto the solar cell?

(1) Some electrons bounded to atoms at the PN junction become free electrons.

(2) There is a net flow of free electrons at the PN junction due to an electric field.

(3) A current flows from the n-type layer to the p-type layer through the motor.

A. (1) and (2) only

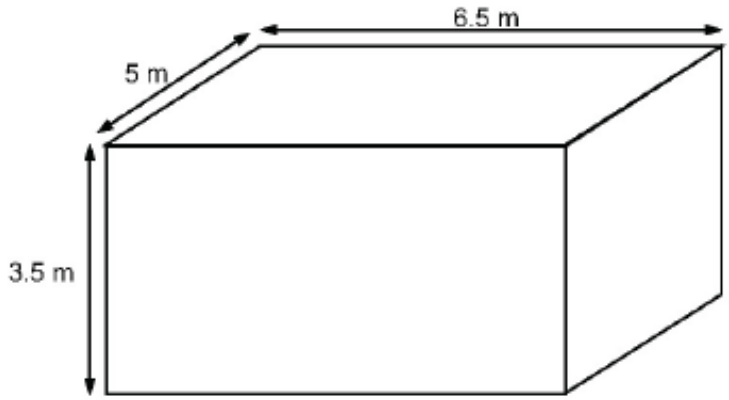
B. (1) and (3) only

C. (2) and (3) only

D. (1), (2) and (3)

A	B	C	D
○	○	○	○

2.5 The figure below shows an incomplete design of a house.



The wall and the roof are made of brick. The designer is considering adding windows to the house (replacing part of the walls). If the OTTV of the house must be kept below 24 W m^{-2}, what is the maximum area of the windows? Take the equivalent temperature difference between the interior and exterior of the house to be 8 K. Neglect the heat transfer through the ground.

Given:

U-value of brick wall / roof = 2.6 W m^{-2} K^{-1}

Rate of heat transfer per unit area through window = 145 W m^{-2}

A. 0.317 m^2

B. 2.49 m^2

C. 2.91 m^2

D. 17.0 m^2

A	B	C	D
○	○	○	○

2.6 Which of the following are the functions of the pressurized water in a pressurized water reactor?

(1) It takes away heat produced by nuclear reactions.

(2) It slows down the neutrons.

(3) It maintains the chain reaction.

A. (1) and (2) only

B. (1) and (3) only

C. (2) and (3) only

D. (1), (2) and (3)

A B C D

2.7 A fluorescent tube lamp contains mercury inside and is coated with phosphor. Which of the following is **NOT** a major step for it to produce light?

A. The movement of electrons and ions forms electric current in the tube.

B. The mercury atoms gain energy from electric current.

C. The electrons in the mercury atoms are emitted and are incident on the phosphor coating.

D. The phosphor coating emits visible light.

A B C D

2.8 In using an electrical appliance, usually part of the energy input to the appliance is wasted. Which of the following is/are the energy wasted in using these electrical appliances?

(1) Heat transferred to the surroundings from the cooking pot when using an induction cooker to cook food.

(2) Energy released in the form of invisible light when using an incandescent lamp for illumination.

(3) Heat removed from a room when using an air conditioner to cool down the room.

A. (1) only

B. (2) only

C. (1) and (2) only

D. (1), (2) and (3)

A B C D

Exam Number			

Q.2 Structured Question

2.9 In a pressurized water reactor, uranium-235 (U-235) is used as the fuel. Controlled nuclear fission takes place in the reactor. A possible fission reaction is described by the following equation.

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{141}_{56}\mathrm{Ba} + {}^{92}_{36}\mathrm{Kr} + 3{}^{1}_{0}\mathrm{n}$$

(a) State a difference between the neutron before the reaction and those released after the reaction. (1 mark)

(b) The table shows the binding energy per nucleon of the nuclides.

Nuclide	Binding energy per nucleon / MeV
U-235	7.590
Kr-92	8.513
Ba-141	8.326

(i) What is the meaning of the binding energy of a nucleus? (1 mark)

(ii) Find the energy released in eV in the reaction. (2 marks)

(iii) The efficiency of the reactor is 40% and 180 g of uranium-235 is consumed each hour in the reactor. Estimate the power output of the reactor. Express the answer in watts. (3 marks)

(c) Explain how control rods are used to control the nuclear fission. (2 marks)

(d) State a function of the pressurized water in the reactor. (1 mark)

***** End of Paper II *****

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
acceleration due to gravity	$g = 9.81\ \text{m s}^{-2}$ (close to the Earth)
universal gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
speed of light in vacuum	$c = 3.00 \times 10^8\ \text{m s}^{-1}$
charge of electron	$e = 1.60 \times 10^{-19}\ \text{C}$
electron rest mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
atomic mass unit	$\text{u} = 1.661 \times 10^{-27}\ \text{kg}$ (1 u is equivalent to 931 MeV)
astronomical unit	$\text{AU} = 1.50 \times 10^{11}\ \text{m}$
light year	$\text{ly} = 9.46 \times 10^{15}\ \text{m}$
parsec	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206\ 265\ \text{AU}$
Stefan constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$

Rectilinear motion

For uniformly accelerated motion:

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \frac{4}{3}\pi r^3$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ (in radians)

Astronomy and Space Science

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma AT^4$	Stefan's law
$\left\|\frac{\Delta f}{f_0}\right\| \approx \frac{v}{c} \approx \left\|\frac{\Delta\lambda}{\lambda_0}\right\|$	Doppler effect

Energy and Use of Energy

$E = \frac{\Phi}{A}$	illuminance
$\frac{Q}{t} = \kappa\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \frac{\kappa}{d}$	thermal transmittance U-value
$P = \frac{1}{2}\eta\rho A v^3$	maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e v_{max}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\text{ eV}$	energy level equation for hydrogen atom
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)

Medical Physics

$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$\text{power} = \frac{1}{f}$	power of a lens
$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

Exam Number			

A1.	$E = mc\Delta T$	energy transfer during heating and cooling
A2.	$E = l\Delta m$	energy transfer during change of state
A3.	$pV = nRT$	equation of state for an ideal gas
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	kinetic theory equation
A5.	$E_K = \frac{3RT}{2N_A}$	molecular kinetic energy

B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	force
B2.	moment $= F \times d$	moment of a force
B3.	$E_P = mgh$	gravitational potential energy
B4.	$E_K = \frac{1}{2}mv^2$	kinetic energy
B5.	$P = Fv$	mechanical power
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration
B7.	$F = \frac{Gm_1m_2}{r^2}$	Newton's law of gravitation

C1.	$\Delta y = \frac{\lambda D}{a}$	fringe width in double-slit interference
C2.	$d \sin\theta = n\lambda$	diffraction grating equation
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens

D1.	$F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
D3.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
D4.	$R = \frac{\rho l}{A}$	resistance and resistivity
D5.	$R = R_1 + R_2$	resistors in series
D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
D7.	$P = IV = I^2R$	power in a circuit
D8.	$F = BQv \sin\theta$	force on a moving charge in a magnetic field
D9.	$F = BIl \sin\theta$	force on a current-carrying conductor in a magnetic field
D10.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
D11.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
D13.	$\frac{V_S}{V_P} \approx \frac{N_S}{N_P}$	ratio of secondary voltage to primary voltage in a transformer

E1.	$N = N_0e^{-\lambda t}$	law of radioactive decay
E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	half-life and decay constant
E3.	$A = kN$	activity and the number of undecayed nuclei
E4.	$\Delta E = \Delta mc^2$	mass-energy relationship