Physics

Higher level

Paper 1A

2 hours [Paper 1A and 1B]

Instructions to candidates

- Do not open the examination paper until instructed to do so.
- Answer all questions
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for paper 1A is **[40 marks]**.
- The maximum mark for paper 1A and paper 1B is **[60 marks]**.

1. Brother is running away from AAHL at 5 m s^{-1}. At the same time, Pablo starts chasing him, starting 50 m behind him and accelerating at 2 m s^{-2}. After how long will Pablo catch Brother and make him learn De Moivre's theorem?
   A. 6.4 s
   B. 10 s
   C. 5 s
   D. 3.7 s

2. A car of mass 2000 kg travelling at 20 m s^{-1} collides with a stationary truck of mass 4000 kg. The two vehicles stick together after the collision. What is the final velocity after the collision?
   A. 10 m s^{-1}
   B. 6.7 m s^{-1}
   C. 20 m s^{-1}
   D. 13.3 m s^{-1}

3. A car is travelling at a constant speed of 20 m s^{-1}. Its engine takes 200 kW of power and the average resistive force acting on the car is 7500 N. What is the efficiency of the engine?
   A. 0.25
   B. 0.50
   C. 0.75
   D. 1.00

4. A constant 20 N force is applied to the rim of a 5 kg disc with radius 50 cm. How long does it take for the wheel to complete 3 full rotations? The moment of inertia for a solid disc is $I = \frac{1}{2}MR^2$.
   A. 0.61 s
   B. 1.1 s
   C. 1.5 s
   D. 2.4 s

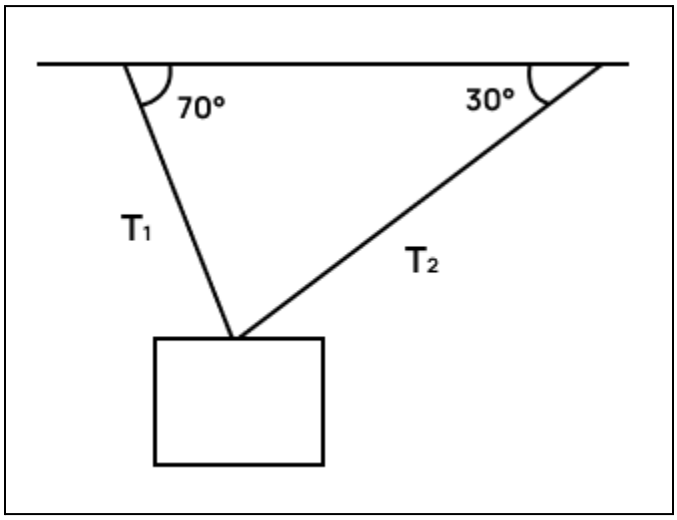
5. A stationary cube of mass 0.5 kg is sandwiched between a rough and a smooth (frictionless) wall. The coefficient of static friction between the cube and the rough wall is 0.5. What is the minimum normal force the smooth wall exerts on the cube?
   A. 9.8 N
   B. 4.9 N
   C. 0.98 N
   D. 0.48 N

6. A 2000 kg truck drives for 400 m up a hill inclined at 5.00° at 10.0 m s^{-1}. At what rate does the truck gain gravitational potential energy?
   A. 196 kW
   B. 17.1 kW
   C. 196 kW
   D. 188 kW

7. Kent and Daniel sit on opposite sides of a seesaw. Kent weighs 75 kg and Daniel weighs 60 kg. Each person sits 1 m away from the pivot of the seesaw. Zac now wants to sit on the seesaw, weighing 75 kg. How far away and on which side must he sit from the pivot in order for the seesaw to be balanced?

	Distance from pivot	Side of seesaw
A	0.1 m	Kent's
B	0.1 m	Daniel's
C	0.2 m	Kent's
D	0.2 m	Daniel's

8. A box is held up by two wires as shown in the below diagram:



What is $\frac{T_1}{T_2}$?

A. $\frac{\sin 30º}{\sin 70º}$

B. $\frac{\cos 30º}{\cos 70º}$

C. $\frac{\sin 70º}{\sin 30º}$

D. $\frac{\cos 70º}{\cos 30º}$

9. A muon travelling at 0.99c penetrates the Earth's upper atmosphere. If muons have a half-life of 1.5 μs in their rest frame, how far would the muon travel in Earth's reference frame before decaying?

A. 450 m

B. 3200 m

C. 1.1×10^{-5}

D. 63 m

10. Events A and B are two lightning strikes. In some inertial reference frame S, A and B have coordinates $x_A = 2.5 \times 10^3\ m, t_A = 0$ and $x_B = 8.0 \times 10^3\ m, t_B = 1.2 \times 10^{-5}\ s$. Is it possible for A and B to occur at the same position and/or the same time in some other inertial reference frame?

	Same position	Same time
A	Possible	Possible
B	Possible	Impossible
C	Impossible	Possible
D	Impossible	Impossible

11. Under which of the following conditions does an ideal gas best approximate a real gas?

	Pressure	Temperature
A	Low	Low
B	Low	High
C	High	Low
D	High	High

12. Which of the following does not contribute to the enhanced greenhouse effect?
    A. Deforestation for urban developments
    B. Exhaust from cars
    C. Intensive farming of animals
    D. Volcanic activity

13. Three statements about entropy are:

    I. The entropy of a non-isolated system can locally decrease.

    II. The change in entropy of a system during a process is directly proportional to the temperature at which a process is carried out.

    III. The entropy of gas molecules in a sealed container is proportional to the number of possible microstates of the molecules.

    Which of these statements is/are correct?

    A. I only

    B. III only

    C. I and II only

    D. I and III only

14. Radiation of intensity I is incident on a surface of area A, emissivity e, and albedo a. What is the equilibrium temperature of the surface?

    A. $\sqrt[4]{\frac{Ia}{e\sigma A}}$

    B. $\sqrt[4]{\frac{I(1-a)}{e\sigma A}}$

    C. $\sqrt[4]{\frac{Ia}{e\sigma}}$

    D. $\sqrt[4]{\frac{I(1-a)}{e\sigma}}$

15. 0.20 kg of an ideal gas in a 0.10 m^3 container has a pressure of 120 kPa at 320 K. What is the best estimate for the molar mass of the gas?g mol^{-1}

    A. 0.044 g mol^{-1}

    B. 0.90 g mol^{-1}

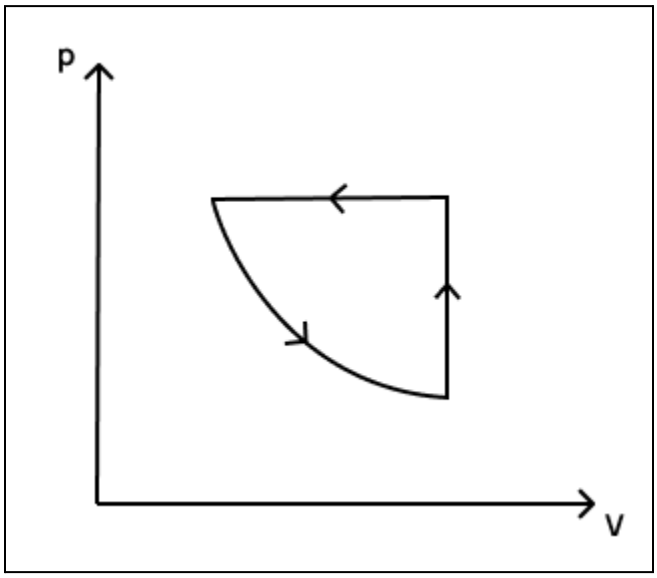
    C. 44 g mol^{-1}

    D. 900 g mol^{-1}

16. A black body X with temperature T emits radiative power P of peak frequency f. An otherwise identical black body Y has temperature 3T. What is the radiative power and peak frequency of black body Y?

	Radiative power	Peak frequency
A	3T	$\frac{f}{3}$
B	3T	3f
C	81T	$\frac{f}{3}$
D	81T	3f

17. The below diagram shows a thermodynamic cycle displayed on a PV diagram. What is true about the work done to the gas and heat transferred to the gas during one cycle?



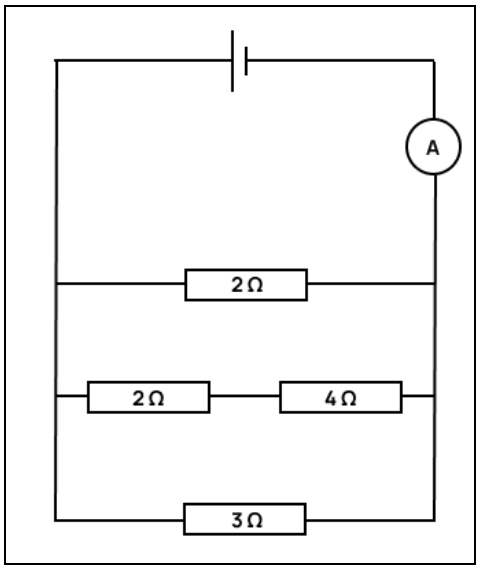
	Work done by the gas	Heat transferred to the gas
A	Negative	Negative
B	Negative	Positive
C	Positive	Negative
D	Positive	Positive

18. What is true about the position and resistance of an ideal voltmeter?

	Position	Resistance
A	In series with component	Zero
B	In series with component	Infinite
C	In parallel with component	Zero
D	In parallel with component	Infinite

19. A heat lamp is situated 2.0 m above a circular dish of water of radius 5.0 cm and depth 1.0 cm. The water heats up from 20°C to 40°C in 20 minutes. The density and specific heat capacity of water are 1000 kg m^{-3} and 4200 J kg^{-1} K^{-1} respectively. Assuming no heat is lost to the environment, what is the best estimate for the power of the heat lamp?
    A. 18 kW
    B. 35 kW
    C. 8.8 kW
    D. 70 kW

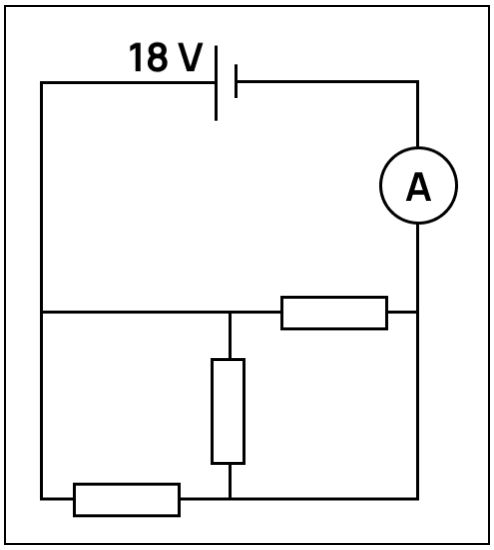
20. A circuit is set up as shown below:



The cell has an internal resistance of 2 Ω and the ammeter reading is 2 A. What is the emf of the cell?

A. 1 V
B. 2 V
C. 3 V
D. 6 V

21. Three resistors each of resistance 6.0 Ω are connected as shown:



What is the ammeter reading?

A. 1.0 A

B. 2.0 A

C. 4.0 A

D. 9.0 A

22. A mass m is attached to a spring with spring constant 50 N m^{-1}. The natural frequency of oscillation of the system is 0.50 Hz. What is m?

A. 2.3 kg

B. 5.1 kg

C. 11 kg

D. 16 kg

23. Three statements about sound waves are:

    I. The displacement of particles is parallel to the direction of energy transfer.

    II. Sound waves can travel without a medium.

    III. The displacement of particles is highest at the center of a compression.

    Which of these statements is/are correct?

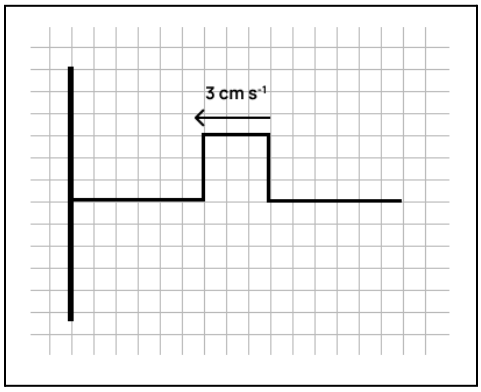
    A. I only

    B. II only

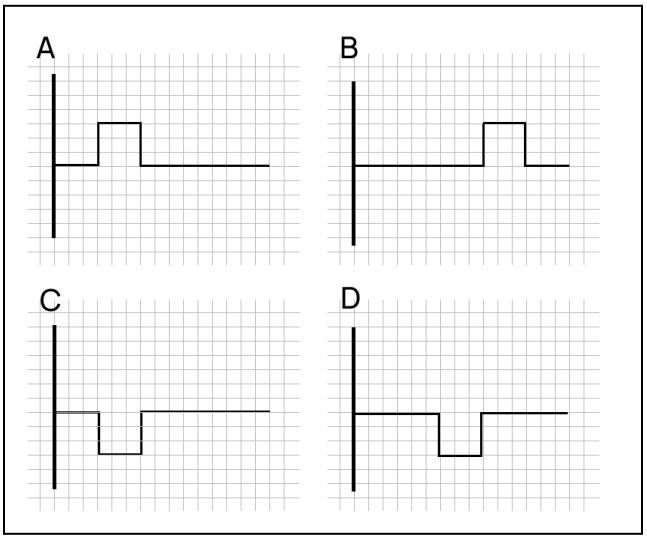
    C. I and III only

    D. II and III only

24. A square wave pulse moves along a string towards a fixed end as shown below. The length of one square is 1.0 cm.



What will be the position of the wave after 4.0 s?



25. Monochromatic light of wavelength λ is incident on a double slit. One slit is filled with a transparent material that shifts the phase of the light by π.
The distance between slits is d and the distance to the screen is D. What is the distance from the center of the interference pattern to the first maximum, and is the central fringe a dark fringe or a bright fringe?

	Distance to first maximum	Central fringe
A	$\frac{D}{2d}$	Dark
B	$\frac{D}{2d}$	Bright
C	$\frac{D}{d}$	Dark
D	$\frac{D}{d}$	Bright

26. A biker rides past a stationary truck. The truck emits a backup alarm of frequency 500 Hz, which the biker detects at approximately 510 Hz. Given that the speed of sound is 340 m s^{-1}, how fast is she traveling and in what direction relative to the truck?

	Speed	Direction
A	6.67 m s^{-1}	Away from the truck
B	6.67 m s^{-1}	Towards the truck
C	6.80 m s^{-1}	Away from the truck
D	6.80 m s^{-1}	Towards the truck

27. Two stars of equal mass m orbit in a binary system around their common center of mass. The radius of the stars' orbits is R. What is the total energy required to separate the stars to infinity?

A. $\frac{GM^2}{2R}$

B. $\frac{GM^2}{R}$

C. $\frac{2GM^2}{R}$

D. $\frac{4GM^2}{R}$

28. A conducting sphere is charged to a charge +q. Three statements about the sphere are:

I. The electric potential at a point outside the sphere is inversely proportional to the distance of the point from the center of the sphere.

II. The electric potential at the center of the sphere is the same as the potential at the surface of the sphere.

III. An electron inside the sphere experiences a force towards the center of the sphere.

Which of these statements is/are correct?

A. I only

B. I and II only

C. II and III only

D. I, II, and III

29. An orbital probe cannon orbits around a planet of mass M at a radius of R. If the cannon has a mass of m, what is its angular momentum?

A. $m\sqrt{GMR}$

B. $M\sqrt{GMR}$

C. $m\sqrt{\frac{GM}{R}}$

D. $M\sqrt{\frac{GM}{R}}$

30. An electron orbits a proton at a distance r. The mass of the electron is m_e. What is the velocity of the electron required to escape the proton's electric field?

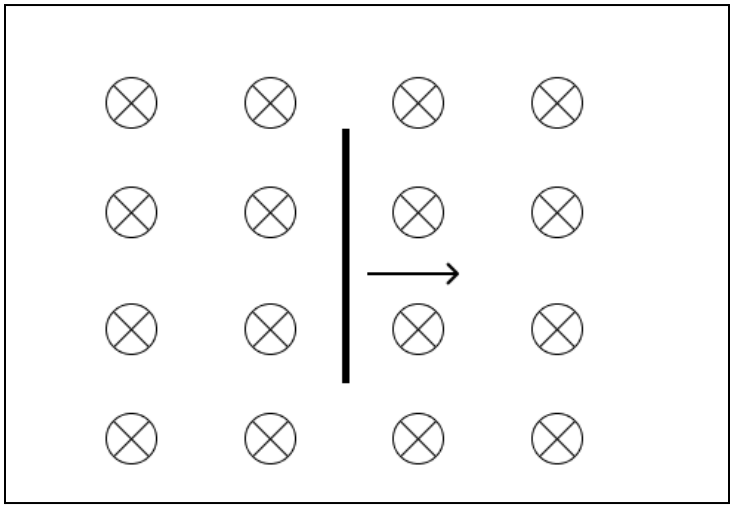
A. $\sqrt{\frac{ke}{r}}$

B. $\sqrt{\frac{2ke}{r}}$

C. $\sqrt{\frac{ke^2}{m_e r}}$

D. $\sqrt{\frac{2ke^2}{m_e r}}$

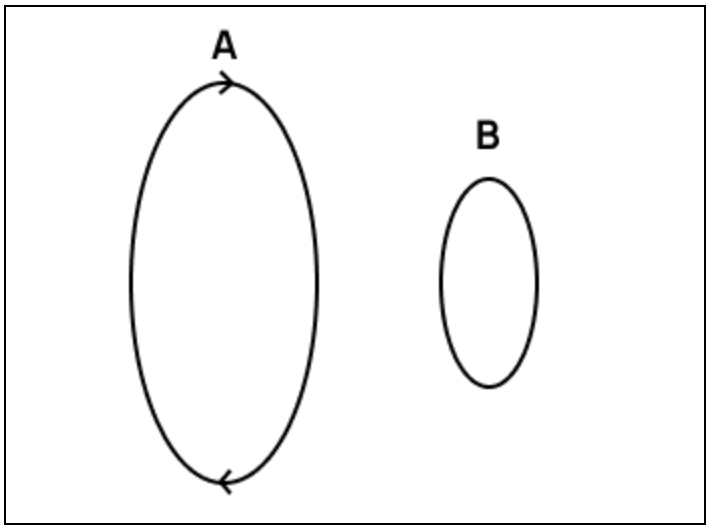
31. A 1.0 m conducting wire moves through a magnetic field of strength 25 mT as shown below.



The wire moves at a speed of 4.0 m s^{-1}. What are the magnitude of the emf and the direction of current inside the wire?

	emf	Current
A	0.10 V	Downwards
B	0.10 V	Upwards
C	160 V	Downwards
D	160 V	Upwards

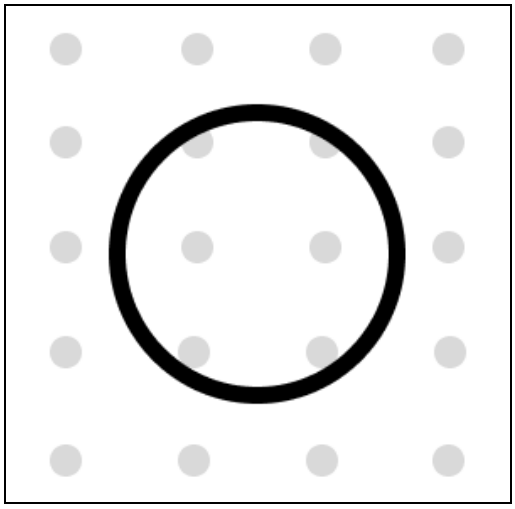
32. Two circular loops of wire A and B are shown below. Loop A is larger than Loop B. A clockwise current flows in Loop A.



The current in Loop A is slowly decreased. What are the direction and magnitude of the current in Loop B?

	Direction	Magnitude
A	Clockwise	Greater than Loop A
B	Clockwise	Smaller than Loop A
C	Counterclockwise	Greater than Loop A
D	Counterclockwise	Smaller than Loop A

33. A circular loop of wire is placed in a magnetic field as shown below.

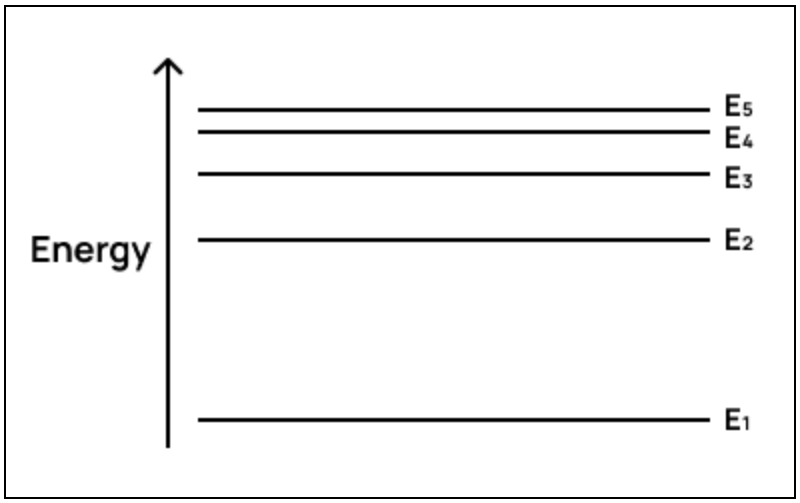


The wire is continuously heated without melting. What will be the change in resistance of the loop and the direction of induced emf in the loop?

	Change in resistance	Direction of emf
A	Increase	Clockwise
B	Increase	Counterclockwise
C	Decrease	Clockwise
D	Decrease	Counterclockwise

34. Which of the following **cannot** be deduced from the results of the Geiger-Marsden-Rutherford experiment?
    A. The nucleus contains protons and neutrons
    B. The nucleus is very small and dense
    C. The nucleus is positively charged
    D. The nucleus contains most of the mass of the atom

35. A simple diagram of five atomic energy levels is shown below.



Which of the below transitions emits the photon of the shortest wavelength?

A. $E_3 \rightarrow E_1$

B. $E_4 \rightarrow E_3$

C. $E_3 \rightarrow E_2$

D. $E_5 \rightarrow E_3$

36. Monochromatic light of wavelength 400 nm is incident on a metal surface. The maximum kinetic energy of electrons emitted from the surface is 0.4 eV. What is the work function of the metal?

A. 0.4 eV

B. 1.6 eV

C. 2.7 eV

D. 3.1 eV

37. An alpha particle is composed of two protons and two neutrons. The mass of a proton is m_P, the mass of a neutron is m_N, and the mass of an alpha particle is m_α. What is the sum of the masses of the individual nucleons compared to the mass of the alpha particle, and what interaction is mainly responsible for this difference in mass?

	Sum of masses	Interaction
A	$2m_P + 2m_N < m_\alpha$	Electromagnetic
B	$2m_P + 2m_N < m_\alpha$	Strong nuclear
C	$2m_P + 2m_N > m_\alpha$	Electromagnetic
D	$2m_P + 2m_N > m_\alpha$	Strong nuclear

38. Astatine-211 has a half-life of 7.2 hours. If the activity of a sample of astatine-211 is $8.0 \times 10^7\ Bq$, how many atoms of astatine-211 are in the sample?

A. 2.1×10^3

B. 3.1×10^3

C. 2.1×10^{12}

D. 3.0×10^{12}

39. Three statements about moderators in nuclear power plants are:

I. A moderator is a good absorber of neutrons.

II. A moderator slows down neutrons.

III. Without a moderator, the power plant will undergo a meltdown.

Which of these statements is/are correct?

A. II only

B. I and II only

C. I and III only

D. II and III only

40. A main sequence star has a mass of $60M_{\odot}$. What is a possible evolution for this star?

A. Red giant → Planetary nebula → White dwarf

B. Red giant → Supernova → Neutron star

C. Red supergiant → Planetary nebula → Neutron star

D. Red supergiant → Supernova → Black hole