IQM3013 Physics

Assessment 2 Paper 1

Candidate question paper

Duration: 2 hours

Total marks: 85

Do not open this paper until instructed. Record every answer in the separate answer booklet.

Instructions

- Answer all questions.
- Section A multiple-choice questions come first. Record the selected option in the separate answer booklet.
- Write all extended responses in the separate answer booklet and identify each question clearly.
- A scientific, non-programmable, non-graphing calculator may be used.
- Use the supplied Physics Data and Formulae Booklet.
- Show all working where relevant.
- No AI is permitted.
- The mark allocation is shown beside each question.

Answer all 25 Section A multiple-choice questions and all six Section B questions.
Record answers in the separate answer booklet, identifying A1–A25 and every Section B part clearly.
Choose one option A–D for each multiple-choice question.
Use the supplied Physics Data and Formulae Booklet and a permitted non-programmable, non-graphing scientific calculator.
No candidate-provided materials, AI, internet or unauthorised electronic assistance are permitted.
Show relevant working, units and suitable significant figures.

Section A · Multiple-choice questions

Answer all 25 multiple-choice questions. 25 marks.

Question A1: Smoke particles viewed under a microscope move irregularly in still air. What best explains this observation? 1

A. The smoke particles are individual air molecules.
B. Unequal impacts by randomly moving air molecules change the particles' motion.
C. Gravity reverses direction rapidly.
D. The air molecules are stationary between collisions.

Question A2: Water has density 1000 kg m^{-3}. Using g = 9.8 m s^{-2}, what is the pressure increase from the surface to a depth of 0.50 m? 1

A. 490 Pa
B. 19 600 Pa
C. 500 Pa
D. 4900 Pa

Question A3: Two objects are in thermal equilibrium. Which quantity must be the same for both? 1

A. Temperature
B. Mass
C. Internal energy
D. Specific heat capacity

Question A4: A pure liquid boils at constant pressure and temperature. What happens to energy transferred to it during vaporisation? 1

A. It increases the average molecular kinetic energy.
B. It reduces the molecular separation.
C. It increases molecular potential energy as attractions are overcome.
D. It is destroyed because temperature is constant.

Question A5: How many particles are present in 0.50 mol of a substance? Use N_a = 6.02×10^{23} mol^{-1}. 1

A. 3.01×10^{23}
B. 1.20×10^{24}
C. 6.02×10^{23}
D. 8.30×10^{-25}

Question A6: In the ideal-gas model, why does a gas exert pressure on a container wall? 1

A. Molecules remain attached to the wall.
B. Molecular weight acts only horizontally.
C. Molecules continuously lose kinetic energy at the wall.
D. Collisions transfer momentum to the wall.

Question A7: A fixed amount of ideal gas is held at constant volume. Its absolute temperature increases from 300 K to 450 K. What is the ratio final pressure / initial pressure? 1

A. 0.667
B. 1.50
C. 2.00
D. 150

Question A8: Which feature of a force–extension graph identifies a region obeying Hooke's law? 1

A. Any curve that slopes upwards
B. A horizontal line
C. A straight line through the origin
D. A line showing permanent extension after unloading

Question A9: Two perpendicular forces of magnitudes 6.0 N and 8.0 N act at a point. What is the magnitude of their resultant? 1

A. 2.0 N
B. 14 N
C. 48 N
D. 10 N

Question A10: What does the signed area under a velocity–time graph represent? 1

A. Displacement
B. Acceleration
C. Speed
D. Resultant force

Question A11: A book rests on a table. Which force is the Newton's third-law partner of the upward force exerted by the table on the book? 1

A. The weight of the table
B. The downward gravitational force on the book
C. The downward force exerted by the book on the table
D. The force exerted by Earth on the table

Question A12: A motor receives 500 J of electrical energy and transfers 350 J to useful mechanical work. What is its efficiency? 1

A. 30%
B. 70%
C. 143%
D. 175%

Question A13: Which statement defines a perfectly elastic collision in an isolated system? 1

A. Total momentum and total kinetic energy are conserved.
B. Only the speed of each body is conserved.
C. The bodies must stick together.
D. Total kinetic energy decreases to zero.

Question A14: A force of 20 N acts on a beam with a perpendicular distance of 0.30 m from its pivot. What is the moment magnitude? 1

A. 66.7 N m
B. 0.015 N m
C. 6.0 N m
D. 20.3 N m

Question A15: A body travels at constant speed in a circle. Which statement describes its acceleration? 1

A. It is zero because speed is constant.
B. It points towards the centre.
C. It points tangentially forwards.
D. It points away from the centre.

Question A16: A mass undergoes simple harmonic motion. Where is the magnitude of its acceleration greatest? 1

A. At equilibrium only
B. Where speed is greatest
C. At every position equally
D. At maximum displacement from equilibrium

Question A17: What is transferred along an ideal progressive wave without a net transfer of the medium? 1

A. Matter only
B. Neither energy nor matter
C. Energy
D. The same individual particles from source to receiver

Question A18: Light travels in a material at 2.00×10^{8} m s^{-1}. Taking $c = 3.00 \times 10^{8}$ m s^{-1}, what is its refractive index? 1

A. 1.50
B. 0.667
C. 5.00
D. 6.00×10^{16}

Question A19: Which electromagnetic radiation has the longest wavelength of the four listed? 1

A. Visible light
B. X-rays
C. Ultraviolet
D. Microwaves

Question A20: Two waves produce displacements +3.0 mm and −1.0 mm at the same point and instant. What is the resultant displacement? 1

A. −4.0 mm
B. +2.0 mm
C. +4.0 mm
D. −2.0 mm

Question A21: Which condition is required for two wave sources to be coherent? 1

A. Equal amplitudes only
B. Identical sources at the same position
C. A constant phase difference and the same frequency
D. Waves travelling at different frequencies

Question A22: A plane wave passes through an opening. When is spreading by diffraction generally most pronounced? 1

A. When the wavelength is much smaller than the opening
B. When the opening is infinitely wide
C. Only when the wave is electromagnetic
D. When the opening width is comparable to the wavelength

Question A23: Adjacent displacement nodes on a stationary wave are 0.20 m apart. What is the wavelength? 1

A. 0.40 m
B. 0.20 m
C. 0.10 m
D. 0.80 m

Question A24: In a metal wire carrying a steady current, how does electron drift relate to conventional current? 1

A. It has no direction.
B. It is opposite to conventional current.
C. It is always perpendicular to conventional current.
D. It is in the same direction as conventional current.

Question A25: A filament lamp is tested at increasing potential difference. Its current increases, but V/I also increases. What best explains this behaviour? 1

A. Its filament resistance decreases as it heats.
B. Its filament remains at constant temperature.
C. Its metal filament heats and its resistance increases.
D. Its current changes direction at each reading.

Section B · Extended-response questions

Answer all 6 extended-response questions. 60 marks.

Question B1: Heating matter and an ideal gas — 10

A heater transfers 9000 J to a 0.50 kg metal block, increasing its temperature by 20 K. Initially neglect heat transfer to the surroundings and apparatus. A separate sample contains 0.200 mol of ideal gas at 300 K and 1.00×10^5 Pa. Use R = 8.31 J mol^{-1} K^{-1}.

(a) Define specific heat capacity. [2]

(b) Calculate the specific heat capacity inferred for the block. [2]

(c) Calculate the gas volume in m^3. [3]

(d) In practice some heater energy warms the apparatus and escapes to the surroundings. Predict how using the full 9000 J affects the inferred block specific heat capacity, and explain. [2]

(e) State what is meant by thermal equilibrium between the block and its surroundings. [1]

Question B2: Motion and a trolley collision — 10

A 0.40 kg trolley starts from rest and accelerates uniformly along a horizontal track at 1.5 m s^{-2} for 2.0 s. It then collides with a stationary 0.60 kg trolley. They couple and move together. Take the initial direction as positive and neglect external impulse during the collision.

(a) Calculate the first trolley’s speed just before the collision and its displacement during the 2.0 s acceleration. [4]

(b) Calculate the velocity of the coupled trolleys immediately after the collision. [3]

(c) Calculate the decrease in total kinetic energy during the collision. [2]

(d) Explain why the decrease in kinetic energy does not violate conservation of energy. [1]

Question B3: A wire under tension — 10

A learner tests a uniform metal wire of original length 2.00 m and diameter 0.500 mm. In its proportional region, a force of 20.0 N produces an extension of 1.02 mm. The wire returns to its original length after unloading.

(a) Define tensile stress and tensile strain. [2]

(b) Calculate the Young modulus of the wire in Pa. [4]

(c) Explain what the return to the original length shows about the deformation. [1]

(d) The learner measures diameter only once and concludes that repeating the extension reading alone will make the Young modulus accurate. Evaluate this claim and describe a better diameter measurement procedure. [3]

Question B4: Interference and stationary waves — 10

Monochromatic light passes through two narrow slits separated by 0.250 mm. A screen is 2.00 m from the slits. The distance from the centre of the first bright fringe to the centre of the sixth bright fringe on the same side of the central maximum is 24.0 mm. In a separate stationary-wave experiment, adjacent displacement nodes on a string are 0.150 m apart.

(a) Calculate the light wavelength in metres using the double-slit small-angle approximation. [3]

(b) Explain why measuring several fringe intervals is preferable to measuring only one when ruler resolution is unchanged. [2]

(c) The light is then incident normally on a grating of spacing 2.00×10^{-6} m. Calculate the first-order diffraction angle. [2]

(d) State how a stationary wave forms on the string, and calculate its wavelength. [3]

Question B5: Circuits and a sensor divider 10

A cell supplies a 4.0 Ω resistor. Its emf is 6.0 V and its internal resistance is 1.0 Ω. In a separate unloaded potential divider across an ideal 6.0 V supply, a 2.0 kΩ fixed resistor is connected in series with an NTC thermistor of resistance 4.0 kΩ. The output is measured across the thermistor using an ideal voltmeter.

(a) Calculate the cell current and the terminal potential difference when supplying the 4.0 Ω resistor. [3]

(b) Calculate the power dissipated in the cell’s internal resistance. [2]

(c) Calculate the unloaded divider output voltage. [2]

(d) Predict and explain how the divider output changes as the thermistor is warmed. [2]

(e) A resistor wire is replaced by wire of the same material and temperature, twice the length and twice the diameter. State the ratio new resistance / original resistance. [1]

Question B6: A capacitor discharge 10

A capacitor of capacitance 1000 μF is initially charged to 6.0 V. It is disconnected from the charging supply and discharged through a 10.0 kΩ resistor. Treat the capacitor and resistor as ideal. A voltage logger has negligible loading.

(a) Define capacitance. [1]

(b) Calculate the initial stored charge and stored energy. [4]

(c) Calculate the time constant and the capacitor voltage after one time constant. [3]

(d) A second logger has a finite input resistance connected in parallel with the discharge resistor. Explain how this changes the time constant and the capacitance inferred if the learner still uses 10.0 kΩ as the discharge resistance. [2]