S4 Physics Practice Paper: Heat and Specific Heat Capacity, Gas Laws, Forces and Motion, Work Energy and Power, Waves and Sound, Basic Electricity

S4 | Physics | Time: 60 minutes | Total: 100 marks | 24 questions

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Part A: Heat and Specific Heat Capacity (16 marks)

Show your working and state the units.

1. 0.5 kg of water is heated from 20 °C to 80 °C. Given the specific heat capacity of water is 4200 J kg^{-1} K^{-1}, find the energy absorbed. [4]

Answer: $E = mc\Delta T = 0.5 \times 4200 \times 60 = 1.26 \times 10^5$ J (126 000 J).

2. 0.2 kg of ice at 0 °C melts completely into water. Given the specific latent heat of fusion of ice is 3.34×10^5 J kg^{-1}, find the energy required. [4]

Answer: $E = mL = 0.2 \times 3.34 \times 10^5 = 6.68 \times 10^4$ J (66 800 J).

3. Explain why a sea breeze (wind blowing from sea to land) usually occurs on a hot sunny day. [4]

Answer: Water has a much larger specific heat capacity than land, so the land heats up faster under the same sunshine. Air over the land expands and rises, and cooler air from the sea flows in to replace it, giving a sea breeze.

4. A thermometer reads 98 °C in boiling water although the true boiling point is 100 °C. Give one possible reason and state how the error can be reduced. [4]

Answer: Reason: the thermometer is not calibrated, or its bulb was not fully immersed in the liquid. Reduce it by calibrating with melting ice (0 °C) and boiling water, and by making sure the bulb is fully immersed without touching the container.

Part B: Gas Laws (16 marks)

Assume ideal gas behaviour and give units in your answers.

5. A fixed mass of gas occupies 2.0 L at 300 K and 1.0×10^5 Pa. It is heated to 400 K at constant pressure. Find the new volume. [4]

Answer: At constant pressure $V_1/T_1 = V_2/T_2$, so $V_2 = 2.0 \times 400 / 300 = 2.67$ L.

6. A gas occupies 6.0 L at 1.0 atm. Its pressure is increased to 3.0 atm at constant temperature. Find the volume. [4]

Answer: Boyle law $p_1V_1 = p_2V_2$: $1.0 \times 6.0 = 3.0 \times V_2$, so $V_2 = 2.0$ L.

7. Convert 27 °C to absolute temperature, and find the absolute temperature of 327 °C. [4]

Answer: $T = \theta + 273$: 27 °C = 300 K; 327 °C = 600 K.

8. Use the kinetic theory of gases to explain why compressing a gas at constant temperature raises its pressure. [4]

Answer: A smaller volume means more molecules per unit volume, so they hit the container walls more frequently. At constant temperature the average kinetic energy, and hence the average force per impact, is unchanged, so the pressure rises.

Part C: Forces and Motion (18 marks)

Take $g = 9.81\ \text{m s}^{-2}$.

9. A car travelling at $20\ \text{m s}^{-1}$ decelerates uniformly at $4\ \text{m s}^{-2}$ to rest. Find the braking time and the stopping distance. [5]

Answer: $t = u/a = 20 / 4 = 5$ s; $s = ut - \tfrac{1}{2}at^2 = 20 \times 5 - \tfrac{1}{2} \times 4 \times 25 = 50$ m.

10. On a velocity–time graph, what do the gradient and the area under the line represent? [4]

Answer: The gradient represents acceleration; the area under the line represents displacement.

11. A body of mass 10 kg is acted on by a resultant force of 30 N. Find its acceleration. [4]

Answer: $a = F/m = 30 / 10 = 3\ \text{m s}^{-2}$.

12. A 60 kg person stands on a scale inside a lift accelerating upwards at $2\ \text{m s}^{-2}$. Find the scale reading in N. [5]

Answer: $N - mg = ma$, so $N = m(g + a) = 60 \times (9.81 + 2) = 708.6\ \text{N} \approx 709\ \text{N}$.

Part D: Work, Energy and Power (16 marks)

Take $g = 9.81\ \text{m s}^{-2}$ and give power in W.

13. A 20 kg box is lifted vertically through 3 m at constant speed. Find the work done. [4]

Answer: $W = mgh = 20 \times 9.81 \times 3 = 588.6\ \text{J} \approx 589\ \text{J}$.

14. A 2000 W kettle heats 1 kg of water from 20 °C to 100 °C. The specific heat capacity of water is $4200\ \text{J kg}^{-1}\,\text{K}^{-1}$. Assuming no heat loss, find the time required. [5]

Answer: $E = mc\Delta T = 1 \times 4200 \times 80 = 3.36 \times 10^5$ J; $t = E/P = 3.36 \times 10^5 / 2000 = 168$ s.

15. A ball of mass 2 kg moves at $6\ \text{m s}^{-1}$. Find its kinetic energy. [4]

Answer: $KE = \tfrac{1}{2}mv^2 = \tfrac{1}{2} \times 2 \times 36 = 36$ J.

16. A machine takes in 500 J of energy and delivers 350 J of useful output. Find its efficiency. [3]

Answer: Efficiency $= 350 / 500 \times 100\% = 70\%$.

Part E: Waves and Sound (17 marks)

Take the speed of sound in air as $340\ \text{m s}^{-1}$.

17. A wave has a frequency of 50 Hz and a wavelength of 4 m. Find its speed. [4]

Answer: $v = f\lambda = 50 \times 4 = 200\ \text{m s}^{-1}$.

18. A person sees lightning and hears the thunder 3 s later. Estimate the distance to the lightning. [4]

Answer: s = vt = 340 × 3 = 1020 m (about 1.0 km).

19. A person shouts towards a cliff and hears the echo 1.5 s later. Find the distance to the cliff. [5]

Answer: The sound travels twice the distance: s = vt/2 = 340 × 1.5 / 2 = 255 m.

20. Explain why sound cannot travel through a vacuum. [4]

Answer: Sound is a longitudinal wave that travels by the vibration of particles in a medium. A vacuum has no particles, so sound cannot travel through it.

Part F: Basic Electricity (17 marks)

Assume the battery and connecting wires have negligible resistance.

21. Two 6 Ω resistors are connected in parallel. Find the equivalent resistance. [4]

Answer: 1/R = 1/6 + 1/6 = 1/3, so R = 3 Ω.

22. A 12 V battery is connected across a 4 Ω resistor. Find the current and the power dissipated. [5]

Answer: I = V/R = 12 / 4 = 3 A; P = VI = 12 × 3 = 36 W.

23. A 2000 W air conditioner runs 3 hours a day. If electricity costs $1.2 per kWh, find the daily cost. [4]

Answer: Energy = 2 kW × 3 h = 6 kWh; cost = 6 × 1.2 = $7.2.

24. A current of 3 A flows through a 5 Ω resistor. Find the potential difference across it. [4]

Answer: V = IR = 3 × 5 = 15 V.
