S4 Physics Practice Paper: Temperature and Heat Capacity, Latent Heat and Change of State, Conduction Convection and Radiation, Gas Laws, Heat and Work, Heat Experiments and Errors (100 marks)

Level: S4 | Subject: Physics | 60 minutes | 100 marks | 24 questions | answer key

Section A: Temperature and Heat Capacity (17 marks)

Each question is worth 4-5 marks; show working and units.

#	Question	Answer	Marks
1	0.50 kg of water is heated from 20 C to 40 C. Given c = 4200 J/(kg K), find the energy needed.	E = mc(dT) = 0.50 x 4200 x 20 = 42 000 J = 42 kJ.	4
2	2.0 kg of a liquid absorbs 168 kJ and its temperature rises by 20 K. Find its specific heat capacity.	c = E / (m dT) = 168 000 / (2.0 x 20) = 4200 J/(kg K).	4
3	0.20 kg of water at 80 C is mixed with 0.30 kg at 20 C, with no heat loss. Find the final temperature.	Heat lost = heat gained: 0.20(80 - T) = 0.30(T - 20); T = (0.20x80 + 0.30x20) / 0.50 = 44 C.	4
4	A 2000 W heater warms 1.5 kg of water from 20 C to 100 C. Find the ideal time and the actual time at 70% efficiency.	E = 1.5 x 4200 x 80 = 504 000 J; ideal t = 504 000 / 2000 = 252 s; at 70% t = 504 000 / 1400 = 360 s.	5

Section B: Latent Heat and Change of State (17 marks)

Each question is worth 4-5 marks; note that temperature is constant during a change of state.

#	Question	Answer	Marks
5	0.25 kg of ice at 0 C melts completely. Given the specific latent heat of fusion is 334 kJ/kg, find the energy needed.	E = mL = 0.25 x 334 = 83.5 kJ. Temperature stays constant; the energy breaks the ice lattice.	4
6	0.10 kg of steam at 100 C condenses to water at 100 C. How much energy is released? (specific latent heat 2260 kJ/kg)	E = mL = 0.10 x 2260 = 226 kJ.	4
7	0.50 kg of ice at -10 C is warmed to water at 20 C. Given ice c = 2100 J/(kg K), Lf = 334 kJ/kg and water c = 4200 J/(kg K), find the total energy.	Ice warms: 0.50 x 2100 x 10 = 10.5 kJ; melt: 167 kJ; water warms: 42 kJ; total 219.5 kJ.	5
8	1.0 g of water evaporating from skin absorbs 2260 J. If all of it heated 100 g of water, what temperature rise results? (c = 4200 J/(kg K))	dT = E / (mc) = 2260 / (0.100 x 4200) = 5.38 K, which is why sweating cools the body well.	4

Section C: Conduction, Convection and Radiation (17 marks)

Each question is worth 4-5 marks; name the heat transfer mechanism.

#	Question	Answer	Marks

9	A copper rod 0.50 m long with cross-section 2.0 cm2 has ends 100 K apart. Given k = 400 W/(m K), find the rate of heat conduction.	P = kA(dT) / L = 400 x 2.0e-4 x 100 / 0.50 = 16 W.	4
10	A rod conducts 40 W at a fixed temperature difference. If it is replaced by one of double the length, same material and area, what is the new rate?	P is proportional to 1/L, so doubling the length halves the rate: 40 / 2 = 20 W.	4
11	An object rises from 300 K to 600 K. If its surface is unchanged, by what factor does the radiated power change?	Radiated power is proportional to T^4, so doubling T gives 2^4 = 16 times.	4
12	A vacuum flask eliminates conduction and convection. Radiation is 30% of the heat loss and silvering cuts it to 3%. Find the percentage reduction and explain the vacuum.	Reduction = (30 - 3) / 30 x 100% = 90%. A vacuum has no particles to conduct and cannot support convection currents, so both modes are blocked.	5

Section D: Gas Laws (17 marks)

Each question is worth 4-5 marks; use absolute temperature.

#	Question	Answer	Marks
13	2.0 L of gas at 300 K and 1.0 atm is heated to 400 K at constant pressure. Find the new volume.	V1/T1 = V2/T2, so V2 = 2.0 x 400 / 300 = 2.667 L.	4
14	Gas sealed in a rigid container is at 100 kPa and 300 K. It is heated to 350 K. Find the new pressure.	P1/T1 = P2/T2, so P2 = 100 x 350 / 300 = 116.7 kPa.	4
15	3.0 L of gas at 1.0 atm is compressed isothermally to 1.5 L. Find the new pressure.	P1V1 = P2V2, so P2 = 1.0 x 3.0 / 1.5 = 2.0 atm.	4
16	24 dm3 of gas is at 300 K and 100 kPa. Use pV = nRT with R = 8.31 J/(mol K) to find the number of moles.	V = 0.024 m3; n = pV / RT = (100 000 x 0.024) / (8.31 x 300) = 2400 / 2493 = 0.963 mol.	5

Section E: Heat, Work and Efficiency (16 marks)

Each question is worth 4 marks; show the calculation steps.

#	Question	Answer	Marks
17	Water falls 50 m; 10% of the lost potential energy becomes heat. Find the temperature rise (g = 9.81 m/s2, c = 4200 J/(kg K)).	Potential energy per kg = 9.81 x 50 = 490.5 J; 10% = 49.05 J; dT = 49.05 / 4200 = 0.0117 K.	4
18	A 2.0 kg metal block sliding at 5 m/s stops, all kinetic energy becoming heat (c = 500 J/(kg K)). Find the temperature rise.	KE = 0.5 x 2.0 x 5^2 = 25 J; dT = 25 / (2.0 x 500) = 0.025 K.	4
19	A 1000 W heater runs for 10 minutes. Find the energy supplied in kJ.	E = Pt = 1000 x 600 = 600 000 J = 600 kJ.	4
20	Burning 0.10 kg of fuel (45 MJ/kg) heats 5.0 kg of water from 20 C to 60 C. Find the efficiency.	Useful = 5.0 x 4200 x 40 = 840 kJ; input = 4.5 MJ; efficiency = 840 / 4500 x 100% = 18.7%.	4

Section F: Heat Experiments and Errors (16 marks)

Each question is worth 4 marks; state the source of error.

#	Question	Answer	Marks
21	A thermometer reads to within +/-0.5 K and a rise of 20 K is measured. Find the maximum percentage error in the rise.	Two readings each off by 0.5 K give 1.0 K; percentage error = 1.0 / 20 x 100% = 5%.	4
22	The same experiment needs 200 s with good insulation and 240 s with poor insulation. Find the extra energy percentage lost.	Extra = (240 - 200) / 200 x 100% = 20% more energy is needed to replace the loss.	4
23	Three results for specific heat capacity are 4180, 4220 and 4500 J/(kg K). Identify the outlier and find the mean of the rest.	4500 is an outlier; the mean of the rest is (4180 + 4220) / 2 = 4200 J/(kg K), which matches the accepted value.	4
24	An appliance uses 2.5 kWh. Using 1 kWh = 3.6 MJ, find the energy in MJ.	E = 2.5 x 3.6 = 9.0 MJ.	4