Assessment Schedule – 2023

Physics: Demonstrate understanding of aspects of heat (90939)

Evidence

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	Convection.	• States / implies convection.		
(b)	In warmer air, particles have a slightly higher energy. Therefore, they move slightly faster, and at slightly larger average distances from each other. Consequently, the density of warmer air is less than that of cooler air, and it rises in cooler air.	• States / implies that [particles] have higher energy in warmer air. OR States / implies that [particles] have a larger average distance from each other in warmer air. OR States / implies that the density of warmer air is less than that of cooler air.	• Links higher energy to larger average distance between particles in warmer air. OR Links larger average distance between particles in warmer air to the density of warmer air being less than that of cooler air.	• Fully linked answer: Links **higher energy** to **larger** average **distance** between particles to **lesser density** in **warmer air** compared to cooler air.
(c)	1 BTU = energy to raise temperature of one pound of water by one degree Fahrenheit. Therefore, 1 BTU = $\Delta E = mc\Delta T = 0.454 \times 4182 \times 0.556 = 1056$ J.	• Calculates the amount of energy correctly using incorrect mass (1 vs. 0.454) and / or incorrect temperature difference (1 vs. 0.556). e.g. $1 \times 4182 \times 0.556 = 2325$ J $0.454 \times 4182 \times 1 = 1899$ J	• Calculates 1056 J correctly.	
(d)	The power of one server is $P = \frac{\Delta E}{\Delta t} = \frac{3.45\times10^7}{60\times60\times24}$ = 400 W. If there are 25 000 servers running, the combined power is $25\,000 \times 400 = 1 \times 10^7$ W = 10 MW. The CRACs require $0.89 \times 1 \times 10^7 = 8.9 \times 10^6$ W or 8.9 MW of power. Therefore, the total power is 10 + 8.9 = 18.9 MW.	• Calculates the power of one server correctly = 400 W or correct process, but from incorrect conversions, an incorrect power of 10, incorrect conversion from h to s, etc.	• Calculates the power of 25 000 servers correctly = 10 MW. OR Calculates the power that the CRACs require correctly, but from an incorrect power of 25 000 servers.	• Calculates 18.9 MW correctly.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No evidence	1a 1m	2a 1a + 1m 1a + 1e 1e	3a 2a + 1m 2a + 1e	4a 2e	2m 1m + 1e 1a + 1m + 1e 1a + 2e	3m	2m + 1e 1m + 2e	1a + 1m +2e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	Specific heat capacity of a substance describes the amount of energy required to **RAISE** the temperature / to heat of 1 kg of that substance by 1 °C	• Gives a definition that links amount of energy to mass and temperature change.		
(b)	The heat generated by the server rack in one minute is $\Delta E = P \times \Delta t = (64 \times 250) \times 60 = 960\ 000$ J. This causes a temperature increase of $\Delta T = \frac{\Delta E}{mc} = \frac{960\ 000}{967 \times 1100} = 0.903\ ^\circ\text{C}$	• Calculates 960 000 J correctly OR Calculates temperature increase correctly from incorrect energy: incorrect number of servers / power, incorrect conversion from min to s, etc.	• Calculates 0.90 °C correctly.	
(c)	The liquid coolant will leave the tank at a lower temperature. Firstly, the liquid coolant has a slightly larger heat capacity than air. Secondly, a tank filled with liquid contains a much larger mass than one filled with the same volume of gas. From $\Delta E = mc\Delta T$, a given amount of heat, ΔE, causes a much smaller increase of temperature, ΔT, when the mass, m, is much larger; $\Delta T \propto \frac{1}{m}$.	• Identifies liquid coolant as leaving the tank at a lower temperature, because its specific heat capacity is larger / liquid coolant requires more energy to increase its temperature. OR Recognises that a given volume of liquid has a larger mass than the same volume of gas.	• Identifies liquid coolant as leaving the tank at a lower temperature, because its specific heat capacity is larger and so it requires more energy to increase its temperature. OR Recognises that a given volume of liquid has a larger mass / amount of matter than the same volume of gas.	• Links larger mass / amount of matter to smaller temperature increase for a given amount of heat.

(d)	Heat is the energy that is associated with the random motion of particles in a substance; the more (or faster) they move, the more heat energy the substance contains. When one fast-moving particle in a warmer body bounces into a particle of a cooler body that is in contact with the warmer one, some of the energy of the faster-moving particle is transferred to the slower-moving one. Thereby, heat is transferred from the warmer to the cooler body. This is called conduction. Compared to a liquid, particles in a gas are spread out over a relatively large volume. Therefore, faster-moving particles in a warmer body bounce into particles in a gas less often per second, making heat transfer to a gas less effective.	• Describes 'heat' as energy associated with random motion of particles / the total energy of the particles. OR Describes 'conduction' as a process of energy transfer due to particles bouncing into each other. OR States / implies that a gas are much less dense / particles further apart compared to a liquid or **vice versa**.	Explains 'conduction' as a process of transfer of energy associated with random motion of particles by means of faster-moving particles / particles with more kinetic energy bouncing into slower-moving particles / particles with less kinetic energy. OR Explains that 'conduction' in a gas is less effective, because gas being much less dense **implies** bouncing into gas particles much less often per second, or vice versa.	• Explains 'conduction' as a process of transfer of energy associated with random motion of particles by means of faster-moving particles bouncing into slower-moving particles. AND Explains that 'conduction' in a gas is less effective, because gas being much less dense, implies bouncing into gas particles much less often per second, or vice versa.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No evidence	1a 1m	2a 1a + 1m 1a + 1e 1e	3a 2a + 1m 2a + 1e	4a 2e	2m 1m + 1e 1a + 1m + 1e 1a + 2e	3m	2m + 1e 1m + 2e	1a + 1m +2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	49 °C.	• Identifies boiling point as 49 °C.		
(b)	In the liquid phase, average inter-particle distances are small, and particles move relatively slowly. Whereas in the vapour phase, particles are very far apart, and move at fast speeds. In the liquid phase, average particle energies are much smaller than in the vapour phase.	• Compares EITHER inter-particle distances and speeds OR inter-particle distances and energies for both phases.	• Compares inter-particle **distances, speeds** and **energies** for both phases.	
(c)	Between 5 and 10 min, the liquid is at its boiling point. There is no increase in temperature due to no increase in the kinetic energy / speed of the particles because the energy provided is used to overcome the attractive forces between the particles in order to evaporate the liquid.	• Links an increase in particle energy / speed to an increase in temperature. OR Explains that energy must be provided to overcome attractive forces. OR States / implies 'latent heat (of evaporation)' as reason for no temperature increase between 5 and 10 min.	• TWO out of the three points.	• Complete answer.
(d)	The time elapsed between 5 and 10 min is $(10 - 5) \times 60 = 300$ s. During this time, the energy supplied to the system is $\Delta E = P \times \Delta t = 14{,}500 \times 300 = 4.35 \times 10^6$ J. Therefore, the mass of liquid evaporated is $m = \frac{\Delta E}{L} = \frac{43.5 \times 10^6}{88\,000} = 49.4 \text{ kg}$.	• Calculates 300 s correctly. OR Calculates the energy supplied correctly from incorrect time. OR Calculates the mass of liquid evaporated correctly from incorrect energy supplied and involving incorrect conversions from kW to W.	• Calculates 4.35×10^6 J correctly. OR Calculates the mass of liquid evaporated correctly from incorrect energy supplied and involving correct conversions from kW to W.	• Calculates 49.4 kg correctly.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No evidence	1a 1m	2a 1a + 1m 1a + 1e 1e	3a 2a + 1m 2a + 1e	4a 2	2m 1m + 1e 1a + 1m + 1e 1a + 2e	3m	2m + 1e 1m + 2e	1a + 1m +2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 14	15 – 19	20 – 24