

2. Thermal Physics

2.1 Kinetic particle model of matter

Paper 3 and 4

Answer Key

Paper 3

Q1.

Question	Answer	Marks
(a)	any three from: <ul style="list-style-type: none"> • random motion (of particles) • high speed • widely separated (compared to particles in liquid or solid) • random arrangement • constantly colliding (with each other / walls) 	B3
(b)	any two from: <ul style="list-style-type: none"> • speed decreases • (because) kinetic energy OR (internal) energy decreases • (and so) collision rate decreases 	B2

Q2.

Question	Answer	Marks
(a)	294 (K)	A2
	273 (+ 21)	(C1)
(b)	<ul style="list-style-type: none"> • low(er) pressure any three from: <ul style="list-style-type: none"> • slow(er)particles or particles have less <u>Kinetic Energy</u> OR less energy in the kinetic store 	B1
	<ul style="list-style-type: none"> • less frequent collisions (with inside of bottle) • (collide with) less force • pressure = force / area OR $p = F \div A$ 	B3

Q3.

Question	Answer	Marks
(a)	any three from (particles / molecules of gas are / have): <ul style="list-style-type: none"> • random arrangement • widely spaced (compared to solid / liquid) • random motion • colliding (with each other / walls) • high speed / KE 	B3
(b)(i)	5.4 (J)	A3
	(work done =) 30×0.18	(C2)
	(work done =) force \times distance (moved in direction of force)	(C1)
(b)(ii)	(pressure) increases	M1
	(because) collisions are more frequent / often (of gas particles with walls)	A1

Q4.

Question	Answer	Mark
(a)	(particles are) fixed in position / in lattice OR regular / fixed arrangement / pattern	B1
	can only vibrate / no translational KE	B1
	close / closer (than in liquids or gases)	B1
(b)(i)	(particles move) closer (as temperature decreases)	B1
	particles vibrate slower / less OR have smaller vibrations	B1
(b)(ii)	(at absolute zero particles have) least / smallest vibrations	B1
(c)	($P =$) $0.62 \text{ (N / cm}^2\text{)}$	A3
	($P =$) $26 \div 42$	(C2)
	($P =$) $F \div A$	(C1)

Q5.

Question	Answer	Marks
(a)	at least 4 circles widely separated (gaps at least the diameter of circles)	B1
	random arrangement	B1
(b)	any three from: regular / uniform arrangement fixed (positions) vibrating close(ly) OR tight(ly) (packed)	B3

Q6.

Question	Answer	Marks
(a)	any three from: <ul style="list-style-type: none"> idea of (continuous) random movement (of gas particles) collisions / impacts (of particles) (collisions) with wall(s) of box idea that force is produced (by colliding particles) idea that pressure is force on an area 	B3
(b)	pressure increases	M1
	(as) <u>more</u> (frequent) collisions (with walls of box)	A1

Q7.

Question	Answer	Marks
(a)(i)	any three from: <ul style="list-style-type: none"> (particles are) fixed in position / place regular arrangement vibrating close(r) than in liquids or gases) 	B3
(a)(ii)	(kinetic energy) decreases	B1
(b)(i)	absolute zero	B1
(b)(ii)	−273 °C OR 0 K OR zero K / kelvin	B1
(c)	black OR dark (colour)	B1
	dull OR rough (surface)	B1

Q8.

(b)(i)	any two from: <ul style="list-style-type: none"> molecules in air moving at high speed / kinetic energy molecules collide with cylinder OR wall (of cylinder) OR piston force of collisions (per unit area) cause pressure. 	B2
(b)(ii)	smaller / lower pressure (on cylinder)	B1
	(because) reduced rate of collisions OR fewer collisions with cylinder OR wall (of cylinder) OR piston (per unit area)	B1

Q9.

Question	Answer	Marks
(b)	(solid:) particles/molecules any three from: (are) fixed in place/position/arrangement regular spacing / pattern / arrangement vibrating close together	B3
	(gas:) particles/molecules any three from: (are) moving randomly at high speed colliding (with each other/walls) randomly arranged/no pattern (relatively) far apart	B3

Q10.

(c)(i)	Brownian (motion)	B1
(c)(ii)	any two from: (fast moving liquid) molecules bombard/collide with (small) particle collisions produce (resultant) force (in random directions)	B2

Q11.

Question	Answer	Marks
(a)	horizontal section at 20 °C	B1
	line starting at (0, 50) line decreasing (steadily) (from (0, 50)) to 20 °C in 30 minutes (by eye) line decreasing from 20 °C AND line reaches 5 °C at time of 80 mins	B3
(b)	any two from: (in solid state molecules / they are) close(r)(than in liquids / gases) (in solid state molecules / they are) in regular arrangement (in solid state molecules / they are) in fixed positions (in solid state molecules / they can only) vibrate	B2

Q12.

Question	Answer	Marks
(a)	Brownian (motion)	B1
(b)	any three from: air molecules (air molecules) collide with (smoke particle) (air molecules) moving randomly (air molecules/collisions) cause change in direction (of smoke particle) (air molecules moving with) high speed idea of more collisions on one side (of particle at a given time)	B3

Q13.

Question	Answer	Marks
(a)	A: melting	B1
	B: evaporating / boiling / vapourising	B1
	C: freezing / solidifying	B1

Q14.

Question	Answer	Marks
(a)	any three from: high speed random movement random arrangement large spaces / gaps between molecules colliding (with each other / walls of container)	B3
(b)	(pressure) increases	B1
	AND any two from: (because) molecules move faster collide more frequently (with walls of container) collide with greater force (with walls of container)	B2

Q15.

Question	Answer	Marks
(a)(i)	high speed	B1
	(in) any or all directions or random (motion)	B1
(a)(ii)	collisions	M1
	(of molecules) with walls of box	A1
(b)	widely separated (owtte) in gas to very close / touching in solid	B1

Q16.

Question	Answer	Marks
(a)	B C A	B2

Q17.

Question	Answer	Marks
(a)	no fixed position	B1
	(average) distance between molecules is greater than that of solids and liquids	B1
	molecules move in any direction owtte at high speeds	B1
(b)(i)	change of direction	B1
	minimum of two straight lines drawn	B1
(b)(ii)	Brownian (movement)	B1

Q18.

Question	Answer	Marks
(a)	solid: molecules closely packed OR fixed positions OR can only vibrate	B1
	liquid: molecules loosely packed OR (more) random (arrangement)	B1
	gas: molecules widely spaced OR further apart than in liquid	B1
(b)(i)	<u>evaporation</u>	B1
(b)(ii)	Any 3 from: more energetic/faster molecules escape from the surface OR liquid (net/average) energy of remaining molecules is lower less (average) energy (gives) lower temperature molecules gain energy (from surroundings) speed of molecules increases	B3

Q19.

Question	Answer	Marks
(a)(i)	regular arrangement of atoms in LH box regular arrangement of atoms in LH box	B1
(a)(ii)	few atoms with no pattern in RH box	B1
(b)	melting below arrow on left	B1
	condensing / condensation below arrow on right	B1
(c)	evaporate / evaporation seen anywhere in explanation	B1
	Any two from: atoms (at the surface) gain KE fastest molecules / molecules with most energy (are able to) escape from surface	B2

Q20.

Question	Answer	Marks
(a)	Any four from: specs/dots (of light) (smoke/air particles) moving (smoke/air particles) randomly (because fast moving) air molecules collide with smoke particles (producing)Brownian motion	4
(b)	evaporate/evaporation	1
	high(er) energy/enough energy/fast(er) moving molecules OR molecules with great(er) KE	1
	escape (from the water surface)	1

Paper 4

Q21.

Question	Answer	Marks
(a)(i)	<i>any three from:</i> <ul style="list-style-type: none"> increase in the (average) KE / speed of air particles more frequent collisions of (air) particles (with bottle) more forceful collisions of (air) particles (with bottle) greater force per unit area gives greater pressure volume unchanged and so pressure increases 	B3
(a)(ii)	(pressure decreases as) air (particles) escape from the bottle / into the air	B1
	until pressure (inside the bottle) is same as (air) pressure outside the bottle OR until pressure (inside the bottle) is same as atmospheric pressure	B1

Q22.

Question	Answer	Marks
(a)	heated / hot(ter) / warm(er) air is less dense OR cool(er) air is more dense	B1
	heated / hot(ter) / warm(er) air rises (to ceiling displacing cooler air) OR cool(er) air falls (displaced by warm(er) air)	B1
(b)(i)	speed / velocity (of particles) increases OR (they) move faster	B1
(b)(ii)	(higher temperature means) particles collide (with rubber) harder / with more force / with greater momentum (change)	B1
	(larger volume means) particles collide (with rubber) less frequently OR (larger volume means) larger (surface) area (for particle collisions)	B1
	effect of larger volume cancels effect of increased temperature / owtte OR the effect of larger area cancels the effect of larger force / owtte OR $P = F / A$ so the two changes cancel each other / owtte	B1

Q23.

Question	Answer	Marks
(a)	pressure decreases AND particles have smaller velocity / momentum / smaller E_k / kinetic energy (when temperature is lower)	B1
	lower rate / frequency of collision of particles	B1
	particles collide with smaller force OR smaller impulse change	B1

Question	Answer	Marks
(b)(i)	$-273 (^{\circ}\text{C})$	B1
(b)(ii)	(temperature at which) particles have least E_k / kinetic energy	B1
	lowest possible temperature	B1
(c)	200 cm^3	A3
	$pV = \text{constant}$ OR $9.0 \times 10^4 \times 350 = 1.6 \times 10^5 \times V_2$	C1
	$V_2 = [9.0 \times 10^4 \times 350] / 1.6 \times 10^5$ OR $V_2 = 2.0 \times 10^8$ OR 1.97×10^8	C1

Q24.

(c)		B3
	(as the volume decreases) the particles collide more often	B1
	(as the temperature decreases) the particles collide less violently	B1
	two effects cancel (to leave the pressure unchanged) or particles collide with walls / piston / cylinder	B1
(d)		B2
	(attractive) forces between (any two) particles large(r than in gases)	B1
	particles close(r) together (than gas particles) or particles already touching	B1

Q25.

Question	Answer	Marks
(a)	any three from: <ul style="list-style-type: none"> moving particles have momentum OR particles hit walls momentum changes when particles hit walls force exerted (by particles) due to (rate of) change of momentum pressure is (total) force (of particles) per unit area (of wall). 	B3
(b)	pressure increases	M1
	(there is a) greater change of momentum OR (particles exert) greater force (on same area) OR particles move faster OR particles have more KE	A1
(c)	(pressure =) $1.5 \times 10^5 \text{ Pa}$	A3
	$p_1 V_1 = p_2 V_2$ OR $(p_2 =) p_1 V_1 / V_2$ OR $pV = \text{constant}$ (for fixed m , fixed T)	C1
	$(p_2 =) 9(.0) \times 10^4 \times 170 / 100$	C1

Q26.

Question	Answer	Marks
(a)	any three of: they / molecules collide with inner surface momentum (of a molecule) changes / reverses force exerted / impulse force spread over area / surface or $p = F / A$	B3
(b)(i)	$(V_2 =) p_1 V_1 / p_2$ in any form or $630 \times 1.0 \times 10^5 / 1.4 \times 10^5$	C1
	450 cm ³ or 4.5×10^{-4} cm ³ or 0.45 dm ³	A1
(b)(ii)	any two of: <u>molecules</u> move more slowly / have less kinetic energy pressure (inside balloon) decreases or pressure is directly proportional to temperature or $p \propto T$ volume is directly proportional to temperature or $V \propto T$ molecular collisions less frequent molecular collisions less violent / hard / exert smaller impulse water / external pressure compresses balloon or water pressure greater (and balloon compressed)	B2

Q27.

Question	Answer	Marks
(a)	molecules close(r)	B1
	molecules move only small distances (between collisions) or do not move freely	B1
	molecules move in clusters or slide past each other	B1
(b)	molecules (in liquid) move faster or gain energy	B1
	molecules move apart (on average)	B1

Q28.

Question	Answer	Marks
(a)(i)	(Molecules) vibrate	1
(a)(ii)	random/haphazard/in all directions	1
	Any one of: with high speed freely zig-zag in straight lines	1
(b)	(Molecules) collide with walls (of box) OR (Molecules) rebound from walls (of box)	1
	Change of momentum (occurs)	1
	force (on walls) = (total) change of momentum per second	1
	Pressure = (total) force ÷ (total) area (of walls)	1