Q1.

2	(a)	speck of light	B1	
		that moves haphazardly/randomly/jerkily/etc.	B1	[2]
	(b)	randomness of collisions would be 'averaged out'	B1	
		so less (haphazard) movement	B1	[2]
		(do not allow 'more massive so less movement')		

Q2.

3	(a)	sum of (random) kinetic and potential energies	M1	
		of the atoms/molecules of the substance	A1	[2]
	(b) (i)	potential energy unchanged as atoms remain in same positions	M1	
		allow 'reduced because atoms slightly closer together'		
		vibrational kinetic energy reduced because temperature lower	M1	
		so internal energy less	A1	[3]
	(ii)	potential energy increases because separation increases	M1	
		kinetic energy unchanged because temperature unchanged	M1	
		so internal energy increases	A1	[3]

Q3.

4	(a)	mass per unit volume (*ratio idea must be clear, not units*)	B1	[1]
	(b) (i)	pressure is same at the surface of mercury		
		because at same horizontal level	B1	[1]
	(ii)	$h\rho g$ is same for both	B1	
		$53 \times 10^{-2} \times 1.0 \times 10^{3} \times g = 71 \times 10^{-2} \times \rho \times g$	C1	
		$\rho = 7.5 \times 10^{2}$ kg m^{-3}	A1	[3]

Q4.

3	(a)	mass / volume (ratio idea essential)	B1	[1]
	(b) (i)	mass = $Ah\rho$	B1	[1]
	(ii)	pressure = force/area	B1	
		weight (of liquid)/force (on base) = $Ah\rho g$	B1	
		pressure = $h\rho g$	A0	[2]
	(c) (i)	ratio = 1600 or 1600:1	A1	[1]
	(ii)	ratio = $\sqrt[3]{1600}$	C1	
		= 11.7 (*allow 12*)	A1	[2]

(d)	**(i)**	density of solids and liquids are (about) equal	B1	[1]
	(ii)	strong forces: fixed volume rigid forces: retains shape / does not flow / little deformation *(allow 1 mark for fixed volume, fixed shape)*	B1 B1	[2]

Q5.

4	**(a)**	**(i)** solid has fixed volume and fixed shape/incompressible	B1	[1]
		(ii) gas fills any space into which it is put	B1	[1]
	(b)	atoms/molecules have (elastic) collisions with the walls (of the vessel) momentum of atom/molecule changes so impulse (on wall)/force on wall random motion/many collisions (per unit time) gives rise to (constant) force/pressure	B1 B1 B1 B1	[4]
	(c)	spacing (much) greater in gases than in liquids/about ten times *either* spacing depends on $1/\sqrt[3]{\rho}$ *or* ratio of spacings is about 8.8	C1 A1	[2]

Q6.

6	**(a)**	any two of: large number of molecules / atoms / particles molecules in random motion no intermolecular forces elastic collisions time of collisions much less than time between collisions volume of molecules much less than volume of containing vessel	B1 + B1	[2]
	(b)	molecules collide with the walls change in momentum of molecules implies force (on molecules) molecules exert equal and opposite force on wall pressure is averaging effect of many collisions (*any three statements, 1 each*)	B3	[3]

Q7.

7	(a)	density in solids and liquids similar	M1	
		spacing in solids and liquids about the same	A1	
		density in gases much less as spacing in gases much greater	B1	[3]
	(b)	density = mass / volume	C1	
		mass = 1.67×10^{-27} kg and volume = $4/3\ \pi\ r^3$	C1	
		density = $(1.67 \times 10^{-27}) / 4/3 \times \pi \times (1.0 \times 10^{-15})^3$		
		= 3.99×10^{17} kg m^{-3}	A1	[3]
	(c)	atoms / molecules composed of large amount of empty space / nucleus has very small volume compared to volume of atom / space between atoms in a gas is very large	B1	[1]

Q8.

3	(a)	$V = h \times A$		
		$m = V \times \rho$	B1	
		$W = h \times A \times \rho \times g$	B1	
		$P = F / A$	B1	
		$P = h\rho g$		
		P is proportional to h if ρ is constant (and g)	B1	[4]
	(b)	density changes with height	B1	
		hence density is not constant with link to formula	B1	[2]

Q9.

4	(a)	pressure = force / area (normal to force)	A1	[1]
	(b)	molecules/atoms/particles in (constant) random/haphazard motion	B1	
		molecules have a change in momentum when they collide with the walls	M1	
		(force exerted on molecules) therefore force on the walls	A1	
		reference to average force from many molecules/many collisions	A1	[4]
	(c)	elastic collision when kinetic energy conserved	B1	
		temperature constant for gas	B1	[2]

Q10.

4	(a)	apparatus: cell with particles e.g. smoke (container must be closed)	B1	
		diagram showing suitable arrangement with light illumination and microscope	B1	[2]
	(b)	specks / flashes of light	M1	
		in random motion	A1	[2]
	(c)	cannot see what is causing smoke to move hence molecules smaller than smoke particles	(B1)	
		continuous motion of smoke particles implies continuous motion of molecules	(B1)	
		random motion of particles implies random motion of molecules	(B1)	
			max. 2	[2]

Q11.

5	(a)		metal: crystalline / lattice / atoms in regular pattern	B1	
			(atoms in regular) pattern that repeats itself (within crystal)	B1	[2]
			polymer: long chains of atoms / molecules	B1	
			chain consists of 'units' that repeat themselves	B1	[2]
	(b)	(i)	e.g. latex is soft / not strong / flows / ductile	B1	
			elastic limit easily exceeded	B1	[2]
			(*allow any two sensible comments, 1 each*)		
		(ii)	more solid / does not flow / stronger / higher ultimate tensile stress		
			more brittle		
			elastic limit much higher		
			increased toughness		
			(*any two, 1 each*)	B2	[2]

Q12.

5	(a)		haphazard / random / erratic / zig-zag movement	M1	
			of (smoke) particles (*do not allow molecules / atoms*)	A1	[2]
	(b)		motion is due to unequal / unbalanced collision rates (on different faces)	B1	
			(unequal collision rate due to) random motion of (gas) molecules / atoms	B1	[2]
	(c)	*either*	collisions with air molecules average out	M1	
			this prevents haphazard motion	A1	[2]
		or	particle is more massive / heavier / has large inertia (M1)		
			collisions cause only small movements / accelerations (A1)		

Q13.

2 **(a)** **(i)** e.g. (phase) change from liquid to gas / vapour
thermal energy required to maintain constant temperature ..... B1 [1]
(*do not allow 'convert water to steam'*)

(ii) e.g. evaporation takes place at surface B1
boiling takes place in body of the liquid B1
e.g. evaporation occurs at all temperatures B1
boiling occurs at one temperature ..... B1 [4]

(b) **(i)** volume = $(\frac{48}{4.5} =)$ 10.7 cm^3 ..... A1 [1]

(ii) **1** volume = $10.7 / (6.0 \times 10^{23})$
= 1.8×10^{-23} cm^3 ..... A1 [1]
2 separation = $\sqrt[3]{(1.8 \times 10^{-23})}$
= 2.6×10^{-8} cm ..... A1 [1]

[Total: 8]

Q14.

2 crystalline: atoms / ions / particles in a regular arrangement / lattice
long range order / orderly pattern
(lattice) repeats itself (1) B1
polymer: long chain molecules / chains of monomers
some cross-linking between chains / tangled chains (1) B1
amorphous: disordered arrangement of molecules / atoms / particles
any ordering is short-range (1) B1
(*three 'B' marks plus any other 2 marks*) B2 [5]

Q15.

1 **(a)** density = mass / volume B1 [1]

(b) density of liquids and solids same order as spacing similar / to about 2× B1
density of gases much less as spacing much more
or density of gases much lower hence spacing much more B1 [2]

(c) **(i)** density = $68 / [50 \times 600 \times 900 \times 10^{-9}]$ C1
= 2520 (allow 2500) kg m^{-3} A1 [2]

(ii) $P = F / A$ C1
$= 68 \times 9.81 / [50 \times 600 \times 10^{-6}]$ C1
$= 2.2 \times 10^4$ Pa A1 [3]

Q16.

3 **(a)** pressure = force / area B1 [1]

(b) molecules collide with object / surface and rebound B1
molecules have change in momentum hence force acts B1
fewer molecules per unit volume on top of mountain / temperature is less hence lower speed of molecules B1
hence less pressure A0 [3]

(c) **(i)** $\rho = m / V$ C1
$W = V\rho g = 0.25 \times 0.45 \times 9.81 \times 13600$ C1
$= 15000$ (15009) N A1 [3]

(ii) $p = W / A$ (or using $p = \rho gh$) $= 15009 / 0.45$
$= 3.3 \times 10^4$ Pa A1 [1]

(iii) pressure will be greater due to the air pressure (acting on the surface of the liquid) B1 [1]

Q17.

3 **(a)** metal: regular / repeated / ordered arrangement / pattern / lattice or long range order (of atoms / molecules / ions) B1
polymer: tangled chains (of atoms / molecules) or long chains (of atoms / molecules / ions) B1
amorphous: disordered / irregular arrangement or short range order (of atoms / molecules / ions) B1 [3]

(b) metal: straight line or straight line then curving with less positive gradient B1
polymer: curve with decreasing gradient with steep increasing gradient at end B1 [2]

Q18.

1 volume = $\pi (14 \times 10^{-3})^2 \times 12 \times 10^{-3}$ ($=7.389 \times 10^{-6}$ m^3) C1
density = mass / volume [any subject] C1
mass = $6.8 \times 10^3 \times 7.389 \times 10^{-6} = 0.0502$
weight = mg C1
$= 0.0502 \times 9.81 = 0.49$ N (mark not awarded if not to **two** s.f.) A1 [4]