BIG IDEA:	**Energy is conserved**
Prior Learning:	Students should by this point by very secure with the particle model and the movement of particles in each state of matter and what happens during changes of states. They should also recall that density is a measure of the amount of substance in a given volume and be able to describe how to measure this for regular and irregular solids.
Future Learning:	This topic has links to chemistry, where students will go on to look at the properties of different materials that influence their melting and boiling points, as well as how different materials are suitable for different purposes because of their properties.
Key misconceptions:	Some common misconceptions in this topic are: - Liquids can be compressed - Fluid refers only to liquids - Particles themselves change during a change of state - Materials always exist as one state of matter
Unit sequencing:	The unit begins with a prior knowledge review of the particle model and the arrangement and movement of particles in each of the states of matter. They will also review ideas about what happens during changes of state, including the internal energy of a system. They will also review density and compare the different states of matter in terms of density, as well as how gases exert pressure. Students will then continue with the review of density, including a theoretical explanation of what the density of a substance actually means before practising the calculation. They will review how to measure or calculate the density of regularly shaped solids (and liquids) and irregularly shaped solids. Students will then use their understanding of the movement of particles in each state of matter to explain how gases exert pressure and the relationship between gas pressure and temperature, linking back to their understanding of the effect of heating on the internal energy of a system. Physics only students will also look at Boyle's law and the mathematical relationship between the pressure and volume of a gas. They will also look at pressure in fluids in greater depth, including how fluids are used in hydraulic systems as force multipliers. These students will also revisit the relationship between the pressure exerted on a surface, the force applied and the surface area, which was previously encountered in P2.1. Physics only students will also then look at the relationships between pressure and depth in a fluid, including pressure and atmospheric height.

Lesson code	**Lesson title**	**What do my students need to <u>know</u> by the end of the lesson?**	**AQA specificaton references**	**What do my students need to be able to <u>do</u> by the end of the lesson?**	**What <u>prior knowledge</u> do I expect my students to have? Where is this likely to have come from?**	**What are the core <u>practical, enquiry and maths skills</u> that students will learn and practise?** **Key:** **Skills in bold are taught for the first time here**	**What practical activities are planned? What apparatus and chemicals are required?**	**What <u>activities</u> could I do in this lesson?**	**What <u>misconceptions</u> may students arrive at the lesson with? What could they leave the lesson thinking if we are not careful? How can I address this directly?** **NOTE: More misconceptions are discussed in the 'notes' section of the powerpoints**	**What <u>exit ticket questions</u> will the students be required to answer by the end of the lesson?**	**What <u>keywords</u> am I introducing in this lesson that students may find difficult?**
P4.1.1	Prior Knowledge Review	Particle diagrams can be used to represent the arrangement and movement of particles in solids, liquids and gases. Solids are the most dense state of matter as the particles are held most closely together due to the forces of attraction.		Draw particle models to represent the arrangement of particles in each state of matter Compare and explain the arrangement and movement of particles in each state of matter Compare the states of matter in terms of density	C1.1: Particle diagrams Changes of state Density and measuring density Gas pressure P3.2: Internal energy			Drawing particle diagrams recap Compare (for each state of matter): - The arrangement of particles - The movement of particles - The forces of attraction between particles - The density Describe and explain what happens to particles/the arrangement of particles during a change of state	Often the particle diagram for a liquid is drawn with the particles spread out too much, so it is too similar to a gas. Particles in a liquid are touching each other, they are just not in a regular arrangement like in a solid. Some students at this stage may still have the embedded misconception that particles themselves change during a change of state rather than just their spacing.	1. In which state(s) of matter are particles able to flow? a. Gases only b. Liquids and gases c. Solids, liquids and gases 2. Which statement is true of a change of state? a. Atoms are rearranged to make new products b. The spacing between particles changes c. New particles are made 3. Which state of matter is the most dense? a. solid b. liquid c. gas	Particle diagram, density, states of matter, forces of attraction
P4.1.2	Density	Density is the mass per unit volume. Density can be calculated using the equation: Density = mass/volume ρ = m/V Density, ρ, in kilograms per metre cubed, kg/m3; mass, m, in kilograms, kg; volume, V, in metres cubed, m3 The density of a regular shaped solid can be calculated by measuring its mass and volume, then using the equation.	4.3.1.1/6.3.1.1	Use the equation density = mass/volume Calculate the density of regularly shaped solids Compare the density of objects with the same mass or same volume	C1.1: Calculating density Measuring density P3.2: Convection is thermal transfer when particles in a heated fluid rise (the area is less dense)	45. Determine densities of solid and liquid objects		Calculating density from given mass and volume Rearranging the equation with mixed examples Practice converting between units Calculation of volume of regularly shaped solids (including cubes, triangular prisms and cylinders) Describe how to measure the mass of an object (drawing out the mass vs weight misconception) Determine order of density of objects all with same mass but different volumes or same volume and different mass.	A common misconception from P3.2 Convection is that the particles themselves become less dense when they are heated. Some students may still be confusing the density in terms of a single particle with the meaning of how many particles (mass) there is in a given volume. IOP guidance is to introduce the concept using three cubes of the same volume before the calculation, which is how density is introduced in C1.1, but some students may need to revisit the theory before using the calculation. This helps students understand that density is a property of materials by itself and is not the same as mass.	1. Which statement is correct? a. Density is a measure of how heavy the particles in a substance are b. Density is a measure of how many particles there are in a given volume c. Density is a measure of how many particles there are in a substance 2. Two cubes have the same volume but different masses. Which statement is correct? a. The cube with the least mass is the most dense b. Both the cubes have the same density c. The cube with the greatest mass is the most dense 3. What is the mass of a block of iron that has a volume of 1 m3? Iron has a density of 7800 kg/m3 a. 7800 kg b. 7.8 kg c. 0.000128 kg	Density, mass, volume, regular, irregular, length, breadth, height
P4.1.3	Measuring Density	The density of an irregular solid or liquid can be determined using its mass and displacement of liquid.	4.3.1.1/6.3.1.1	Describe how to measure the density of an irregularly shaped solid Measure volume accurately Describe how to read the volume of a liquid Compare the methods to calculate the densities of a regular and an irregular object	C1.1: Calculating density Measuring density		RPA5/17: Measuring density	Practical activity (could be done as demo if needed) Write a method to explain how you would calculate the density of a regular vs an irregular shaped solid Practice reading volume using the meniscus	Some students think that the water displacement method only works for irregular shaped objects. It can be worth explaining that you could use the same method for a regularly shaped object, but it would be easier to just use a calculation.	1. Which measurement is taken using a displacment or eureka can? a. density b. mass c. volume 2. Which statement is correct? a. The volume of water displaced by an irregular shaped object is the same as the volume of the object b. The volume of water left in the eureka can is the same as the volume of the object c. Using the volume of water displaced by an object only works if the object has an irregular shape 3. What is the density of an object that has a mass of 5 g and displaces 25 cm3 of water? a. 125 g/cm3 b. 0.2 g/cm3 c. 5 g/cm3	irregular, displacement, eureka can
P4.1.4	Gas Pressure	Gas pressure is caused by collisions of particles with the walls of a container Pressure is measured in Pascals (Pa) Changing the temperature of a gas at constant volume changes the pressure exerted by the gas Particles at higher temperatures, have higher thermal energy and move more quickly. They have a higher pressure **In a sealed container, with the same number of particles at constant temperature, decreasing the volume of a gas increases the pressure of the gas** **The pressure of the gas is inversely proportional to its volume. This is because when the volume is decreased, the gas particles will collide more frequently with the walls of the container. More collisions mean more force, so the pressure increases** ***Work is the transfer of energy by a force.*** ***Doing work on a gas increases the internal energy of the gas and can cause an increase in the temperature of the gas.*** ***Increasing the volume in which a gas is contained, at constant temperature, can lead to a decrease in pressure.*** **p1V1=p2V2, where P1 and V1 are the initial pressure and volume values, and P2 and V2 are the pressure and volume values after change**	4.3.3.1/6.3.1.1 4.3.3.2 4.3.3.3	Combined Science: Explain what is meant by gas pressure Describe the relationship between temperature and gas pressure Describe how heating affects the kinetic energy and speed of particles Explain how temperature is related to kinetic energy of particles *Physics only:* *Describe and explain the relationship between pressure and volume* *Describe and explain the relationship between temperature and pressure* *Use the equation p1V1=p2V2*	C1.1: Gas pressure and movment of particles P3.2: Internal energy Relationship between temperature and kinetic energy			Review of movement of particles in liquids and gases Review of internal energy and the link between kinetic energy and temperature Demonstration of gas pressure. See https://thescienceteacher.co.uk/gas-pressure/ for some examples Physics only: See lesson moved from P3.2 for mixed p1V1=p2V2 calculations	Some students think that pressure is only exerted by one solid on another solid. Some students think that if a substance is heated, the particles themselves expand and conflate these larger particles with exerting more pressure.	1. Which describes the movement of particles in a gas? a. All particles move randomly at the same speed b. All particles move at different speeds in a pattern c. All particles move at random speeds in random directions 2. What would happen to the pressure inside a sealed pot if it was heated? a. The pressure would increase b. The pressure would decrease c. The pressure would stay the same 3. Which statement is correct? a. When particles are heated they expand b. When particles are heated their internal energy increases c. When particles are heated they exert less pressure on the walls of a container	Fluid, compressible, incompressible, pressure, force, collision, kinetic energy

P4.1.5	Taking it further: Pressure	**A fluid is a substance with no fixed shape - a liquid or a gas Fluid particles exert a force on any surface they collide with. This force is always at right angles to the surface Pressure exerted on a solid is calculated using the equation pressure= force/area Liquids are incompressible so can be used to transmit forces through hydraulic systems The pressure remains constant in the system so if the area increases, the force is multiplied, which is how heavy objects can be lifted or controlled**	4.5.5.1.1	*Use the equation pressure = force/area for pressure exerted on a solid Explain why hydraulic brake systems use liquids*	P2.1: Pressure and applications of pressure			Review of pressure = force/area calculations from P2.1 Scenario based questions with transmission of forces through fluids (e.g. different hydraulic systems)	Some students think that liquids can be compressed (and therefore change the pressure) because they are not held in a regular arrangement. This stems from inaccurate particle diagrams - liquid particles must be touching each other but not in a regular arrangement.	1. What properties of liquids makes them suitable for using in hydraulic systems? a. They can be compressed b. They cannot be compressed c. They do not have a fixed shape 2. Pressure is exerted by a fluid on a surface. If the area of the surface remains constant but a greater force is applied, what happens to the pressure? a. The pressure increases b. The pressure decreases c. The pressure stays the same 3. What force must be applied to a balloon to exert 50 N/cm2 of pressure on an area of 0.1 cm2? a. 5 N b. 0.002 N c. 500 N	Pressure, fluid, incompressible, hydraulics, force transmission
P4.1.6	Taking it further: Pressure in fluids	***The deeper you go in water the greater the pressure becomes, because the greater the weight of water above you The pressure due to a column of liquid can be calculated using the equation: pressure (Pa) = height of the column (m) × density of the liquid (kg/m3) × gravitational field strength (N/kg). This equation can be represented as: p = hρg pressure, p, in Pascals, Pa; height of the column, h, in metres, m; density, ρ, in kilograms per metre cubed, kg/m3; gravitational field strength, g, in newtons per kilogram, N/kg In a liquid, pressure at a point increases with the height of the column of liquid above that point and with the density of the liquid because there are more particles exerting a downward force A partially (or totally) submerged object experiences a greater pressure on the bottom surface than on the top surface. This creates a resultant force upwards. This force is called the upthrust*** **The atmosphere is a thin layer (relative to the size of the Earth) of air round the Earth. The atmosphere gets less dense with increasing altitude Air molecules colliding with a surface create atmospheric pressure The number of air molecules (and so the weight of air) above a surface decreases as the height of the surface above ground level increases. So as height increases there is always less air above a surface than there is at a lower height. So atmospheric pressure decreases with an increase in height**	4.5.5.1.2 4.5.5.2	*Calculate the pressure at different depths of a liquid using the equation pressure = height x density x gravitational field strength Describe the relationship between pressure and depth Describe the relationship between pressure and atmospheric height Describe the forces acting on objects when they float or sink. Describe how upthrust is related to the pressure exerted on the surfaces of a (partially) submerged object*	P1.2: Gravity and gravitational field strength			Physics only: See lesson moved from P3.2 for calculations Describing relationship between depth in a fluid and pressure Describing relationship between atmospheric height and pressure	Some students think pressure is only acts downwards, which can stem from them not understanding relative directions of different forces and assuming that weight is the only force acting on an object. Some students confuse the idea of density and weight, meaning that they think objects that are 'heavier' than water will sink.	1. A student cuts three holes in a bottle of water. Where is the pressure greatest? a. At the highest hole b. At the middle hole c. At the lowest hole 2. An inflatable toy floats on water. Which statement is correct? a. The weight of the toy is equal to the upthrust on the toy b. The weight of the toy is less than the upthrust on the toy c. The weight of the toy is greater than the upthrust on the toy 3. How deep is an object under water if it experiences 29910 N/m2 of pressure? The density of water is 997 kg/m3 and the gravitational field strength is 10 N/kg. a. 2.98 x10^8 m b. 3 m c. 0.33 m	pressure, depth, density, weight, upthrust, atmosphere
P4.1.7	Feedback Lesson										