A. Particle model of matter – Density of materials and changes of state
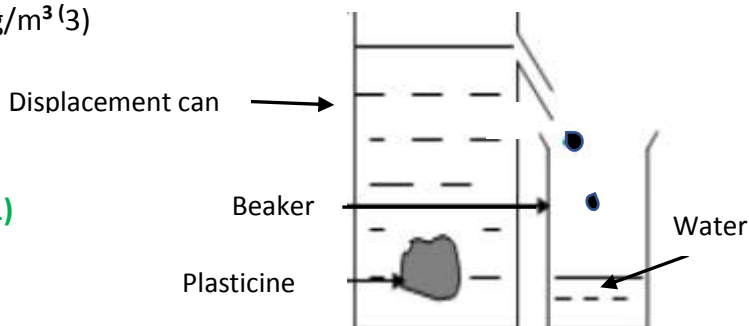
1. A 45 g piece of plasticine is placed in water and 30 cm³ of water was displaced.
   Calculate the density of the plasticine in kg/m³ (3)

Density = mass / volume (1)

45 g =0.045 kg   30 cm³ = 0.00003 m³ (1)

Density = 0.045 kg / 0.00003 m³

= 1500 kg/m³ (1)

Displacement can

Beaker

Plasticine

Water

2. The density of solid copper is 8960 kg/m³.
   The density of molten copper is 7900 kg/m³.

   Explain this difference in density by referring to the particle model and the arrangement of atoms in the two states. (2)

   **Solid copper is more dense than liquid copper as the particles are packed closer together. (1)
   In molten (liquid) copper the particles are free to move past each other so are not as densely packed. (1)**

3. House bricks have a density of 2100 kg/m³. If you require 15 m³ to build a house, what will the mass of these bricks be? (3)

   $p = m / v$ $m = p \times v$ (1)   mass = 2100 x 15 (1)   mass of bricks = 31 500 kg (1)
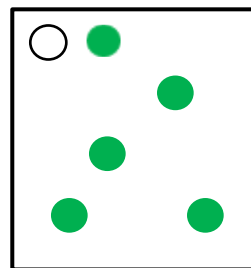
4. The particles in candle wax can be in solid, liquid or gaseous state. In the boxes below, draw the arrangement of particles you would expect in each of these three states. (3)
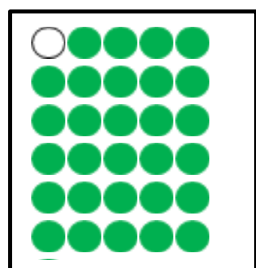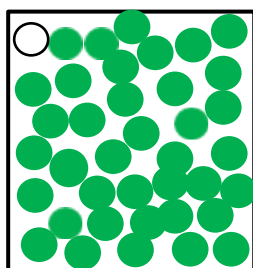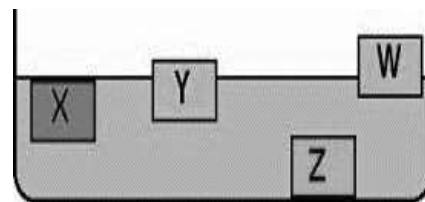
SOLID   LIQUID   GAS

5. The diagram shows four different substances which have been placed in a basin of water. Which one of the following statements is TRUE? (1)

   A. Z is the densest and X is the least dense.

   B. Y is the least dense and Z is the densest.

   C. X has the same density as the water and W is the least dense. (1)

   D. Z is the densest and Y is the next densest.

6. When a small block of iron is heated it becomes a liquid, but when thin iron wire is heated it becomes a black powder. Explain these observations in terms of physical and chemical changes. (3)

   Block of iron melts which is a physical change. (1)
   When iron wire is heated a new substance is formed. (1)
   The iron wire cannot easily be turned back to wire so it is a chemical change. (1)

B. Particle model of matter – Internal energy and energy transfer

7. In a closed energy system, E_p describes the potential energy of the particles and E_k the kinetic energy of the particles. How would you use these two values to calculate the total internal energy of the system (U)? (2)

   E_p and E_k should be added together (1)
   To make up the total internal energy of the system. (1)

8. A cold spoon and an ice cube are placed in a cup of boiling water. Describe the effect the changes in internal energy will have on the spoon and the ice cube. (3)

   Cold spoon
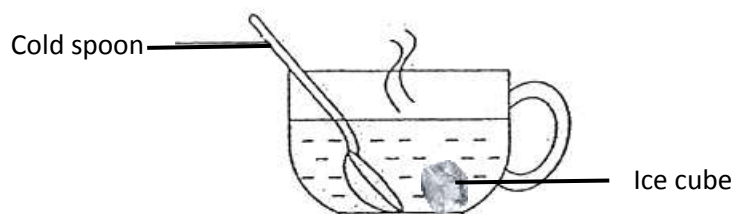
   Ice cube

   Both will have the energy of their particles increased. (1)
   In the spoon, this increase will raise the temperature. (1)
   In the ice cube, the increase in internal energy will cause a state change. The ice will melt and could cause an increase in temperature if the ice is not at its melting point. (1)

9. Which of the following statements best describes the term "specific heat capacity" (1)

    A – the amount of internal heat energy contained in 1 kg of a substance.

    B – the amount of heat energy conducted from 1 kg of an object to another.

    C – The amount of heat energy needed to raise the temperature of 1 kg of a substance by 1 ^{0}C. (1)

    D - The time taken to raise the temperature of a block of metal by 1 ^{0}C.

10. A storage heater contains concrete bricks which heat up at night and slowly release their heat the following day.
    The bricks have a mass of 20 kg and they have 480 000 J of heat energy transferred to them overnight.
    Calculate the maximum temperature rise of the bricks. (3)

    (Concrete has a specific heat capacity of 960 J/kg ^{0}C)

    Change in thermal energy = mass x specific heat capacity x temperature rise

    Temperature rise =   change in thermal energy   (1)
    Mass x specific heat capacity

    Temperature rise = 480 000   (1)
    20 x 960

    Temperature rise of bricks = 25°C (1)

11. Describe what is meant by the specific latent heat of a substance. (1)

    The energy needed to change the state of 1 kg of a substance. (1)

12. A 200 g sample of ice is at a temperature of 0 ^{0}C. How much heat energy will be required to melt this sample of ice without raising its temperature?
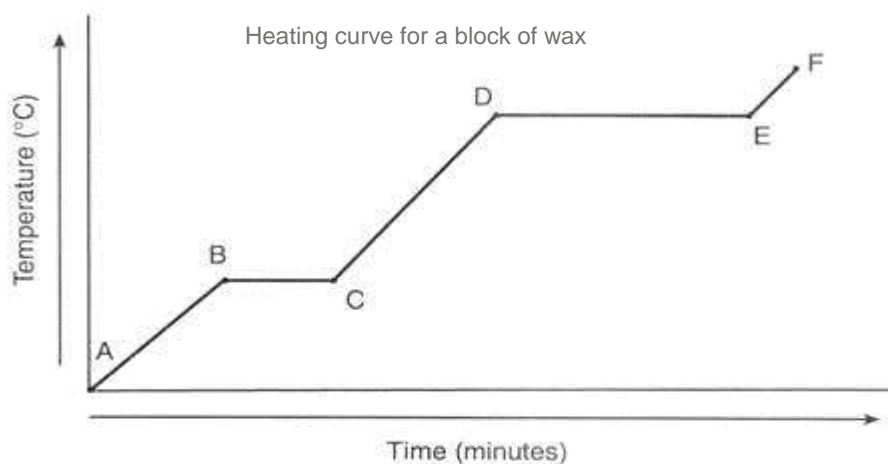   The specific latent heat of melting ice is 334 000 J/kg. (2)

    Energy to change state = mass x specific latent heat

    200 g = 0.2 kg (1)

    Energy = 0.2 x 334 000 =   66 800 J of energy (1)

13. The graph shows the temperature of a block of solid wax as it is heated.

Heating curve for a block of wax

a. What state will the wax be in between points E and F on the graph? (1)

    Gas (1)

b. Why is the temperature between B and C not rising? (2)

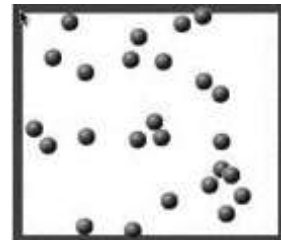   **Energy is being used to change the state of the wax (1)**
    Breaking / weakening the intermolecular bonds between the particles. (1)

c. Which point shows the maximum temperature of liquid wax? (1)

    D (1)

C. Particle model of matter – Particle model and pressure

14. The diagram shows particles of a gas moving around inside a sealed container.

    a. If the container is heated up, which of the statements below is true? (1)

        A. The gas particles move closer together.

        B. The gas particles move slower.

        C. The gas particles have more kinetic energy. (1)

        D. The gas particles expand.

    b. What happens to the pressure in the box as the gas is heated? (1)

        A. Pressure increases as gas particles have higher speed collisions with the container walls (1)

        B. Pressure is the same as there are the same number of particles in the box

        C. Pressure increases as the gas particles expand

        D. Pressure is the same because the mass of each particle does not change

15. The diagram shows a gas bottle filled with propane gas at a temperature of 12 ^{0}C.
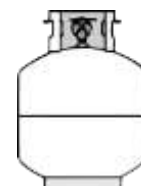
   The bottle is left in the sunshine and the temperature of the gas gradually increases.
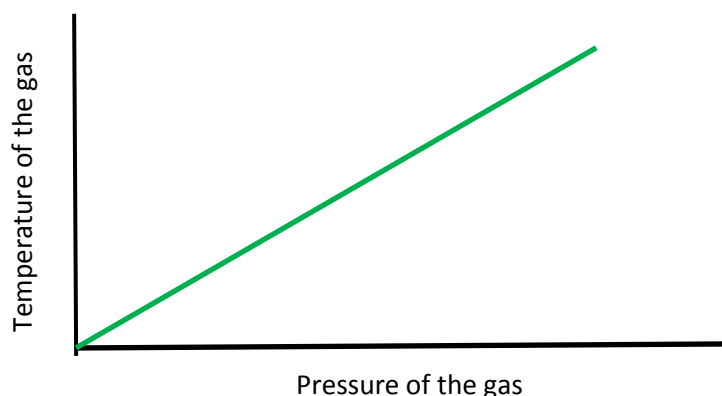
    a. What will happen to the number of particles of gas in the bottle? (1)
       Remains the same. (1)
    b. What will happen to the pressure of gas inside the bottle as the temperature rises? (1)
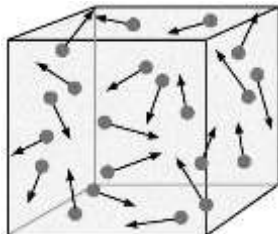   **Pressure will increase. (1)**
    c. On the graph below, sketch the shape you would expect if temperature and pressure were plotted as the temperature gradually rises. (1)

(1)

Physics only

16. The diagram shows the movement of gas particles inside a fixed metal container at 20 ^{0}C.
The temperature is increased to 50 ^{0}C.

a. Describe the change in average velocity of the gas particles as a result of this temperature change. (1)

Average velocity will increase. (1)

b. Explain why the pressure on the walls of the container increases with this temperature change. (3)

Particles have more kinetic energy / move faster. (1)

**They will collide with the walls of the container more often and with greater force. (1)**

Pressure will increase as pressure = force / area, and the force per unit area has increased. (1)

17. A piston contains 1 litre of air. The plunger is lifted so the same mass of gas now occupies 3 litres.

    a. Use the particle model to explain why the pressure on the piston wall will be reduced when the plunger is lifted. (2)

    Same number of particles in a greater space. (1)

    Fewer collisions with container walls in a given time so pressure will be less (1)
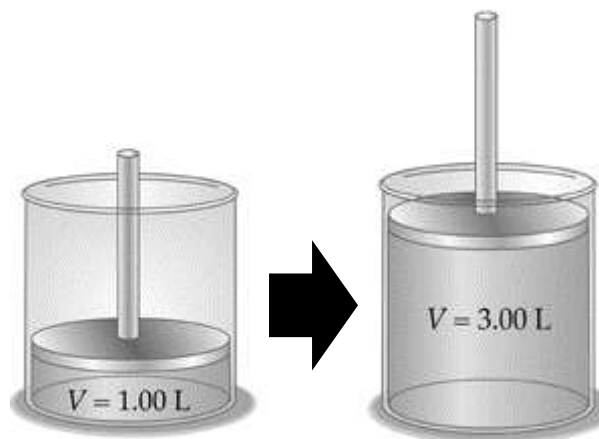
    b. In what direction is the force exerted on the piston walls? (1)

    At right angles (perpendicular) to the container walls. (1)

    c. If the pressure of the gas when it occupies a volume of I litre is 100 000 Pa, calculate the gas pressure when the volume is 3 litres. (2)

    Pressure x volume = constant

    $P_1 V_1 = P_2 V_2$ **$P_2 = \dfrac{P_1 V_1}{V_2}$ (1)**

    $P_2 = \dfrac{100\ 000 \times 1}{3}$ = 33 333Pa (1)

Physics only (Higher tier)

18. In a car diesel engine, work is done on the fuel/air mixture to ignite it. Explain why the fuel ignites when there is no spark in the diesel engine. (3)

    Work done by piston is used to compress the fuel/air mixture. (1)

    A compressed gas has more kinetic energy so the temperature increases. (1)

    Increased temperature of gas is hot enough to ignite fuel/air mixture. (1)