How Does Temperature Affect Viscosity, Density and Buoyancy?

307-9 Explain the effects of changes in temperature on the density of solids, liquids and gases and relate the result to the particle model of matter.
Do you think fluids run more easily if they are hot or cold?

Viscosity, density and buoyancy all change in temperature.
When do fluids run more easily?

Fluids run more easily when they are warm.
Decreasing Temperature

- As heat is taken away from a fluid, its particles slow down and come closer together.
- This causes the fluid to contract – its **volume** decreases.
- This causes the **density to increase**
  
  \[ D = \frac{M}{V} \text{ if } V \text{ gets smaller, } \frac{M}{V} \text{ gets bigger} \]
- Viscosity will also be affected, as particles slow down and come closer together, it gets harder for them to move past each other. Therefore, **viscosity increases**.
Increasing Temperature

- As heat is added to a fluid, its particles speed up and spread out.
- This causes the fluid to expand – its volume increases.
- This causes the density to decrease (D=M/V if V gets bigger, M/V gets smaller)
- Viscosity will also be affected, as particles speed up and move apart, it gets easier for them to move past each other. Therefore, viscosity decreases.
How does a hot air balloon rise and fall?

As air is heated and released inside the balloon, the balloon rises. This happens because hot air is less dense than the surrounding air. As the air inside the balloon cools, it becomes denser and the balloon descends.
Water: A Special Case

- Water acts differently than other fluids when heated and cooled.
- Warm water floats on top of cooler water (think of a lake in the summer). But, when the temperature gets below 4°C, water becomes less dense again!
Why does warmer water float on top of colder water?

Warmer water floats on top of colder water because warmer water is less dense than colder water.
Why does ice float?

Ice floats because it is less dense than liquid water. Water is most dense at 4° Celsius.
Lakes

- Lakes will not freeze solid in the winter. As water cools it sinks to the bottom. The deepest part of a lake will always be 4°C. This allows aquatic life to survive. The ice on top of the lake insulates the water beneath. Only shallow ponds will freeze solid.
The viscosity of water also changes with temperature. Water at 0 degrees Celsius is 7 times more viscous than water at 100 degrees Celsius.
Understanding Concepts
Copy Table 2 and complete it by adding up or down arrows to indicate how each property changes with temperature.

<table>
<thead>
<tr>
<th></th>
<th>Volume</th>
<th>Density</th>
<th>Viscosity</th>
<th>Buoyancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp.</td>
<td>![Up Arrow](Up Arrow)</td>
<td>![Up Arrow](Up Arrow)</td>
<td>![Down Arrow](Down Arrow)</td>
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<td>Temp.</td>
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<td>![Up Arrow](Up Arrow)</td>
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Use the particle theory to explain the effects of temperature changes on the cooking oil in Investigation 2.4

As the temperature of the oil increased, the particles making up the oil gained more energy and vibrated faster. As the temperature rose, the force of attraction between the particles became weaker, leaving larger spaces between them. This decreased the resistance that the oil had to flowing, resulting in a decreased viscosity.
How does water behave differently than other fluids when the temperature changes?

Water is densest at 4°C. Above and below this temperature, water is less dense. Other fluids do not behave this way when heat is taken away.
Making Connections
In many aircrafts, oxygen masks are stored in compartments above the passengers. The oxygen for these masks is stored as a liquid. When it is needed, it is warmed up until it is a gas. Explain why oxygen is stored as a liquid rather than a gas in this situation.

Storing oxygen as a liquid rather than a gas enables more oxygen to be stored.