# Gases and absolute scale of temperature

## • The effect on the pressure of a gas of a change of temperature at constant volume-(Pressure law)

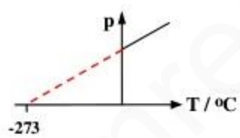
The pressure law states the pressure of a fixed mass of a gas is directly proportional to its absolute temperature if the volume is kept constant.

$P \propto T$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

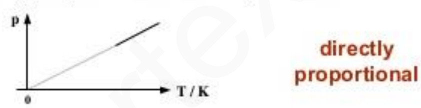
**Graphs of Pressure Law**

The straight line graph does not pass through the origin.




If the graph is extended back until the pressure reaches zero, it will cross the axis at -273°C. This is known as absolute zero.

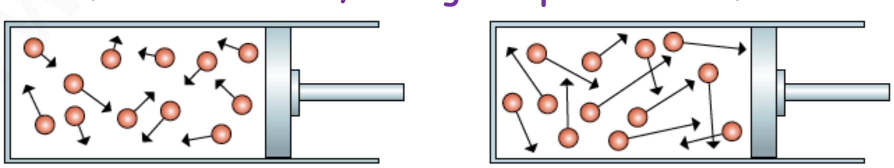
If the pressure against temperature in kelvin graph is drawn, the graph will show pressure being directly proportional to temperature.




Once the volume is fixed and if you:

Increase the temperature you are giving more energy to the particles in the gas. By doing so their kinetic energies increase which will make them move faster and will collide with the walls of their container more frequently, causing the pressure to rise .

Decrease the temperature , the gas molecules will move slowly. Hence there will be fewer collisions ,causing the pressure to fall.



increased temperature → increased KE → increased pressure pV = constant for a fixed mass of gas at constant temperature including a graphical representation of this relationship

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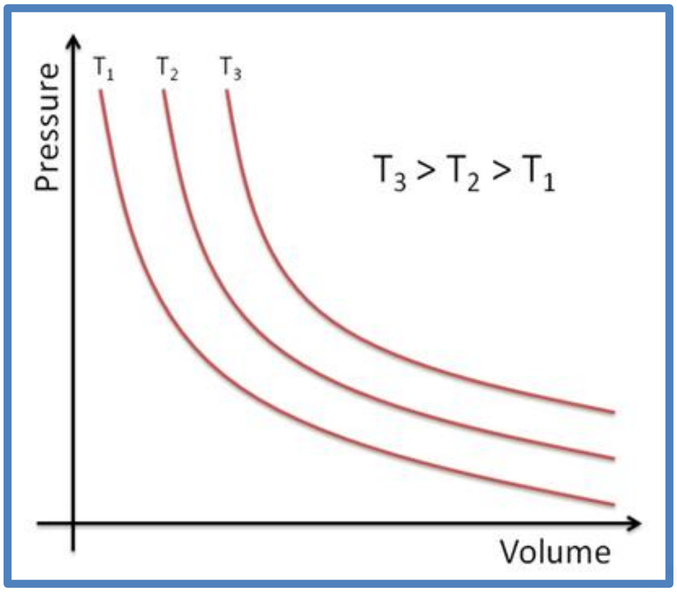
**The effect on the pressure of a gas of a change of volume at constant temperature-(Boyles law)**



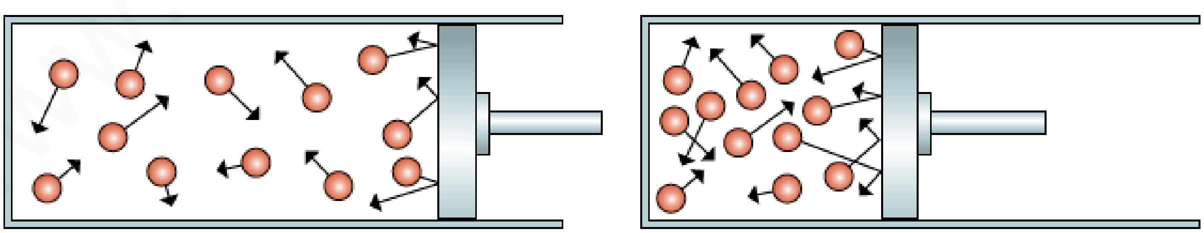

$V \propto \frac{1}{P}$, temperature =constant

HENCE;
PV=constant for a fixed mass of a gas at constant temperature

- For a given mass of gas at a constant temperature, the product of the pressure and the volume is a constant. As the volume decreases, the pressure increases in proportion, and vice versa.
- For example, when the pressure halves, the volume doubles.

Another explanation:

As the volume of a gas is reduced the gas will become denser, because the molecules are pushed together. The molecules will therefore collide with each other more often and also hit the walls more often, increasing the rate of change of momentum and hence the pressure as shown.



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## NUMCERICALS ON GAS LAWS:

**(b)** Air in a cylinder is compressed slowly, so that the temperature does not rise. The pressure changes from $2.0 \times 10^5$ Pa to $5.0 \times 10^5$ Pa. The original volume was $0.35\,m^3$. Calculate the new volume.

**O/N/04-P3-Q5**

$P_1V_1=P_2V_2$ WHERE;

$P_1=2 \times 10^5$ ; $V_1=0.35$ ; $P_2=5 \times 10^5$

FIND $V_2$

$\Rightarrow 2 \times 10^5 \times 0.35 = 5 \times 10^5 \times V_2$

$V_2 = 0.14\,m^3$

volume = ..........................[3]

## APPLICATION BASED QUESTIONS:

**MCQ:**

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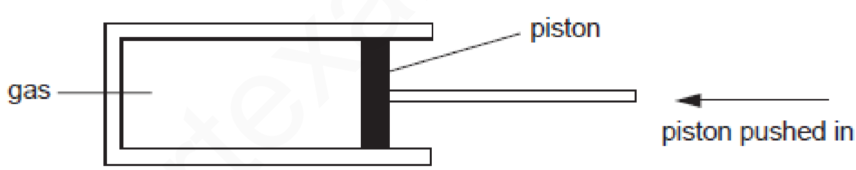
**15** A measured mass of gas is placed in a cylinder at atmospheric pressure and is then slowly compressed.

**0625/1/O/N/02**




If the temperature of the gas does not change, what happens to the pressure of the gas?

**A** It drops to zero.

**B** It decreases, but not to zero.

**C** It stays the same.

**D** It increases.

**15** Driving a car raises the temperature of the tyres. **0625/01/O/N/03**

This causes the pressure of the air in the tyres to increase.

Why is this?

**A** Air molecules break up to form separate atoms.

**B** Air molecules expand with the rise in temperature.

**C** The force between the air molecules increases.

**D** The speed of the air molecules increases.

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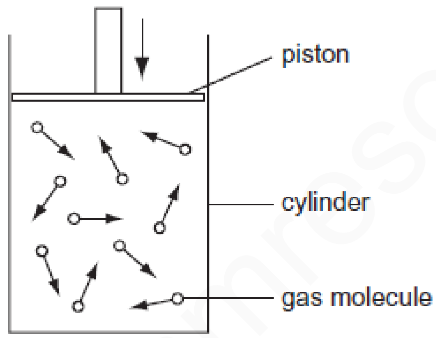
**14** The diagram represents gas molecules contained in a cylinder. The piston is moved slowly downwards and the temperature of the gas stays the same.

**0625/01/O/N/04**




Why does the pressure of the gas increase?

**A** The molecules collide harder with the walls.

**B** The molecules collide more often with the walls.

**C** The molecules move more quickly.

**D** The number of molecules increases.

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**14** A car tyre contains a constant volume of air.

**0625/13/O/N/12**

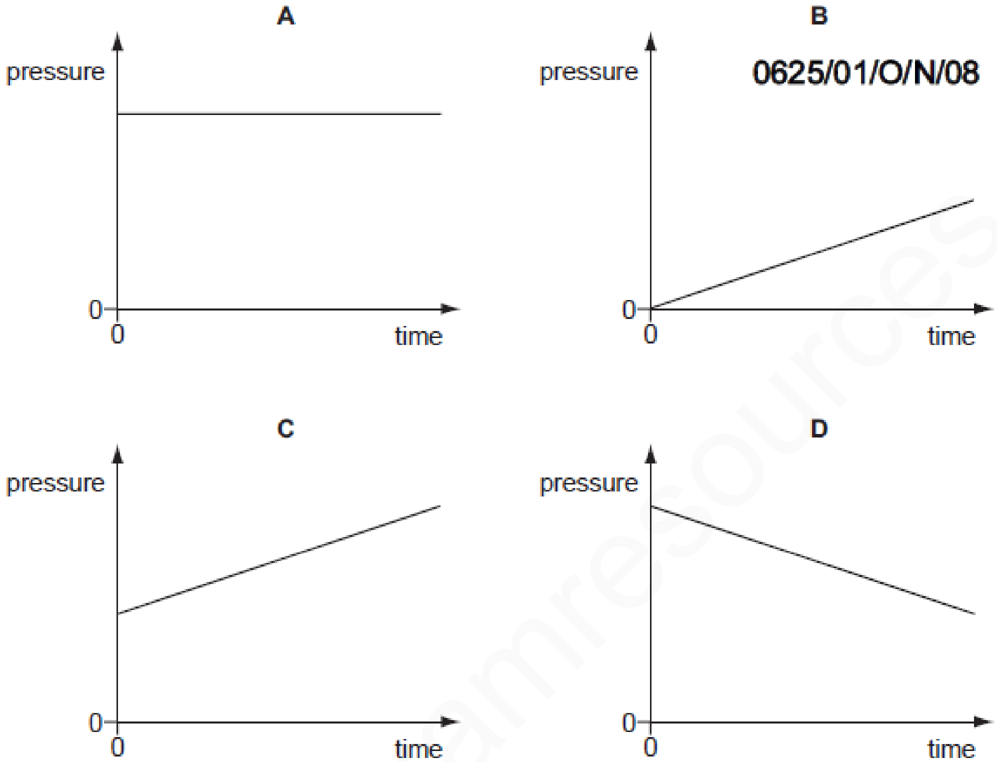
During use, the air gets hotter and the air pressure increases.

What explains this increase in pressure in terms of the motion of air molecules?

| | number of air molecules in tyre | force between air molecules and tyre wall | number of collisions per second between air molecules and tyre wall |
|---|---|---|---|
| **A** | increased | increased | decreased |
| **B** | increased | unchanged | decreased |
| **C** | unchanged | increased | increased |
| **D** | unchanged | unchanged | increased |

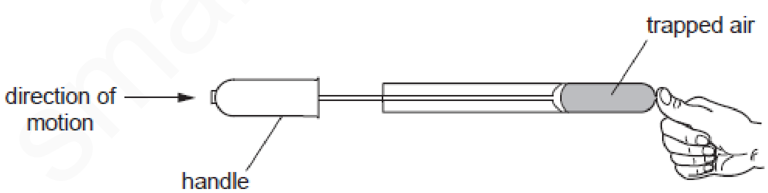
15 The pressure of a fixed mass of gas in a cylinder is measured. The volume of the gas in the cylinder is then slowly decreased.

Which graph could show the change of pressure of the gas during this process?




12 A student places his thumb firmly on the outlet of a bicycle pump, to stop the air coming out.

0625/12/M/J/14




What happens to the pressure and what happens to the volume of the trapped air as the pump handle is pushed in?

| | pressure | volume |
|---|---|---|
| **A** | decreases | decreases |
| **B** | decreases | remains the same |
| **C** | increases | decreases |
| **D** | increases | remains the same |

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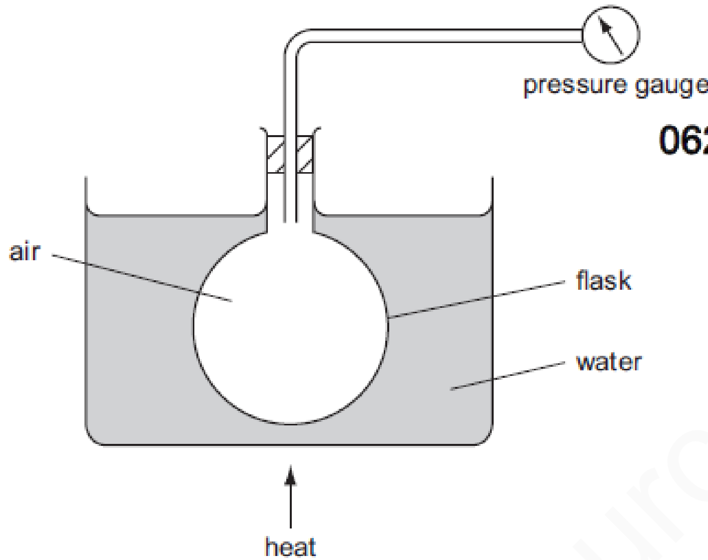
**17** An experiment is set up as shown.

**0625/01/M/J/05**




What does the pressure gauge show as the air in the flask becomes hotter?

**A** a steady pressure

**B** a decrease in pressure

**C** an increase in pressure

**D** an increase and then a decrease in pressure

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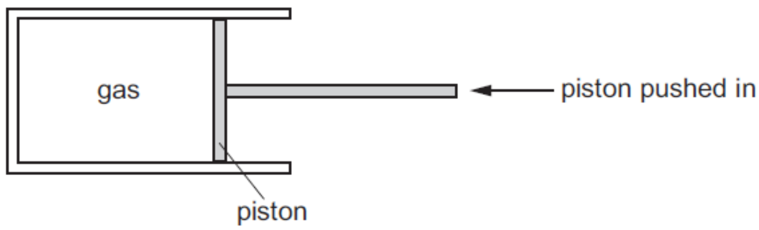
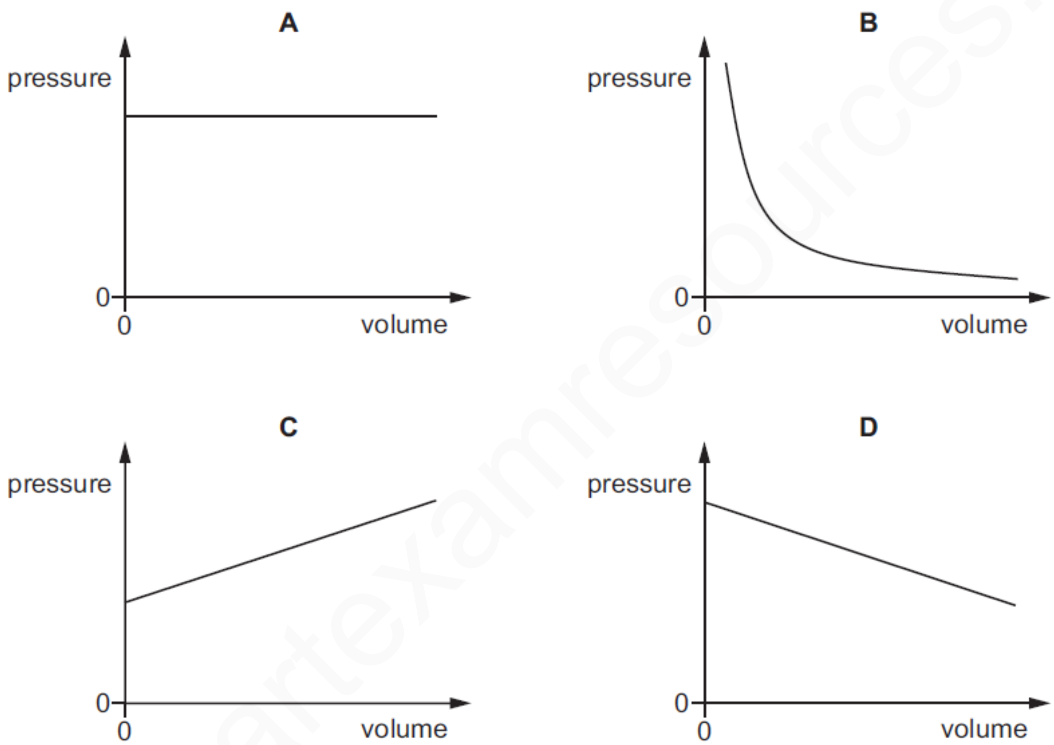
**15** The diagram shows a quantity of gas trapped in a cylinder. The piston is pushed in slowly and the gas is compressed. The temperature of the gas does not change.

**F/M/16-P22**




Which graph shows the relationship between the pressure and the volume of the gas?

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EXTENDED THEORY

5 Fig. 5.1 shows a way of indicating the positions and direction of movement of some molecules in a gas at one instant.

O/N/05-P3

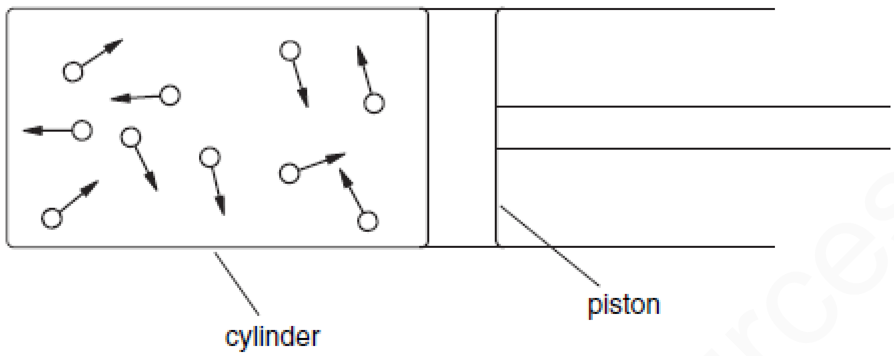


**Fig. 5.1**

**(a)** **(i)** Describe the movement of the molecules.

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**(ii)** Explain how the molecules exert a pressure on the container walls.

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**(b)** When the gas in the cylinder is heated, it pushes the piston further out of the cylinder.

State what happens to

**(i)** the average spacing of the molecules,

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**(ii)** the average speed of the molecules.

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4 Fig. 4.1 shows a sealed steel cylinder filled with high pressure steam.


**Fig. 4.1**

Fig. 4.2 shows the same cylinder much later when all the steam has condensed.

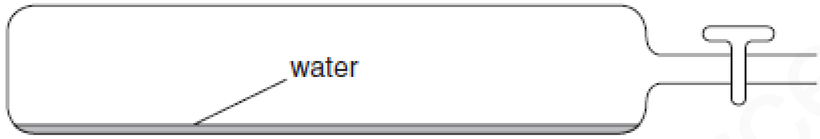


**Fig. 4.2**

**(a)** **(i)** Describe the movement of the molecules in the high pressure steam.

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**(ii)** Explain how the molecules in the steam exert a high pressure on the inside walls of the cylinder.

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**(b)** Describe, in terms of particles, the process by which heat is transferred through the cylinder wall.

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**4** A sealed balloon containing some helium gas is released and rises into the upper atmosphere. As the balloon rises the temperature of the helium falls and the balloon expands.

Explain, in terms of atoms,

**O/N/11-P32**

**(a)** the effect of the fall in temperature on the helium pressure,

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**(b)** the effect of the expansion of the balloon on the helium pressure.

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[Total: 6]

4 (a) Fig. 4.1 shows some gas contained in a cylinder by a heavy piston. The piston can move up and down in the cylinder with negligible friction.

O/N/12-p32

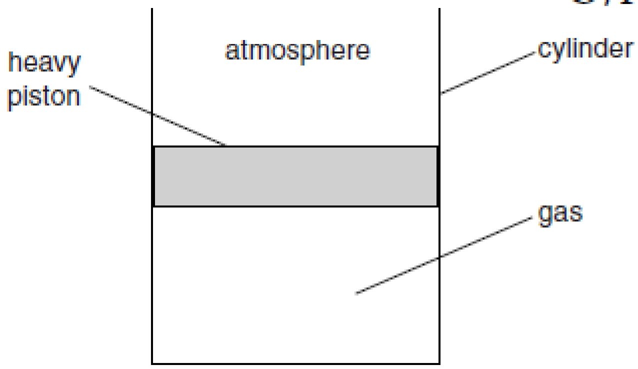


**Fig. 4.1**

There is a small increase in the pressure of the atmosphere above the piston.

(i) On Fig. 4.1, draw a possible new position for the lower face of the piston. [1]

(ii) Explain, in terms of the molecules of the gas and the molecules of the atmosphere, your answer to **(a)(i)**.

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**(b)** Fig. 5.1 shows a quantity of gas in a cylinder sealed by a piston that is free to move.

O/N/15-P31-Q5

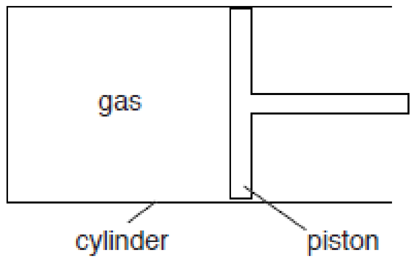


**Fig. 5.1**

**(i)** The temperature of the gas is increased.

State what happens, if anything,

**1.** to the piston,

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**2.** to the pressure of the gas.

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[2]

**(ii)** The piston is now fixed in place and the temperature of the gas is increased further.

Explain, in terms of the behaviour of molecules, what happens to the pressure of the gas.

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# TEMPERATURES/SCALES/CONVERSION

- Temperature refers to the degree of hotness or coldness of a substance.
- The motion of the particles is increased by raising the temperature. Conversely, the motion of the particles is reduced by lowering the temperature, until, at the absolute zero (0 K), the motion of the particles cease altogether.
- Since the particles are in motion, they have kinetic energy. Also, all the particles will not have the same energy. Also the energy of the particles is constantly changing as they undergo changes in speed. Thus, for a given sample of matter, we can only talk about the average kinetic energy of the particles. Temperature is thus defined as a measure of the average kinetic energy of the particles.
- Three scales used to record temperatures are:

✓ **The Celsius scale.** On this scale, melting ice (in equilibrium with water vapour at one atmosphere pressure) has a temperature of 0.0 °C, and boiling water (at normal atmospheric pressure) has a temperature of 100.0 °C.

✓ **The Fahrenheit scale**: This scale records the melting ice at a temperature of 32 °F and boiling water at a temperature of 212 °F.

✓ **The Kelvin scale:** On this scale, melting ice has a temperature of 273.16 °C.

✓ There is a lowest possible temperature (−273°C), known as absolute zero, where the particles have least kinetic energy

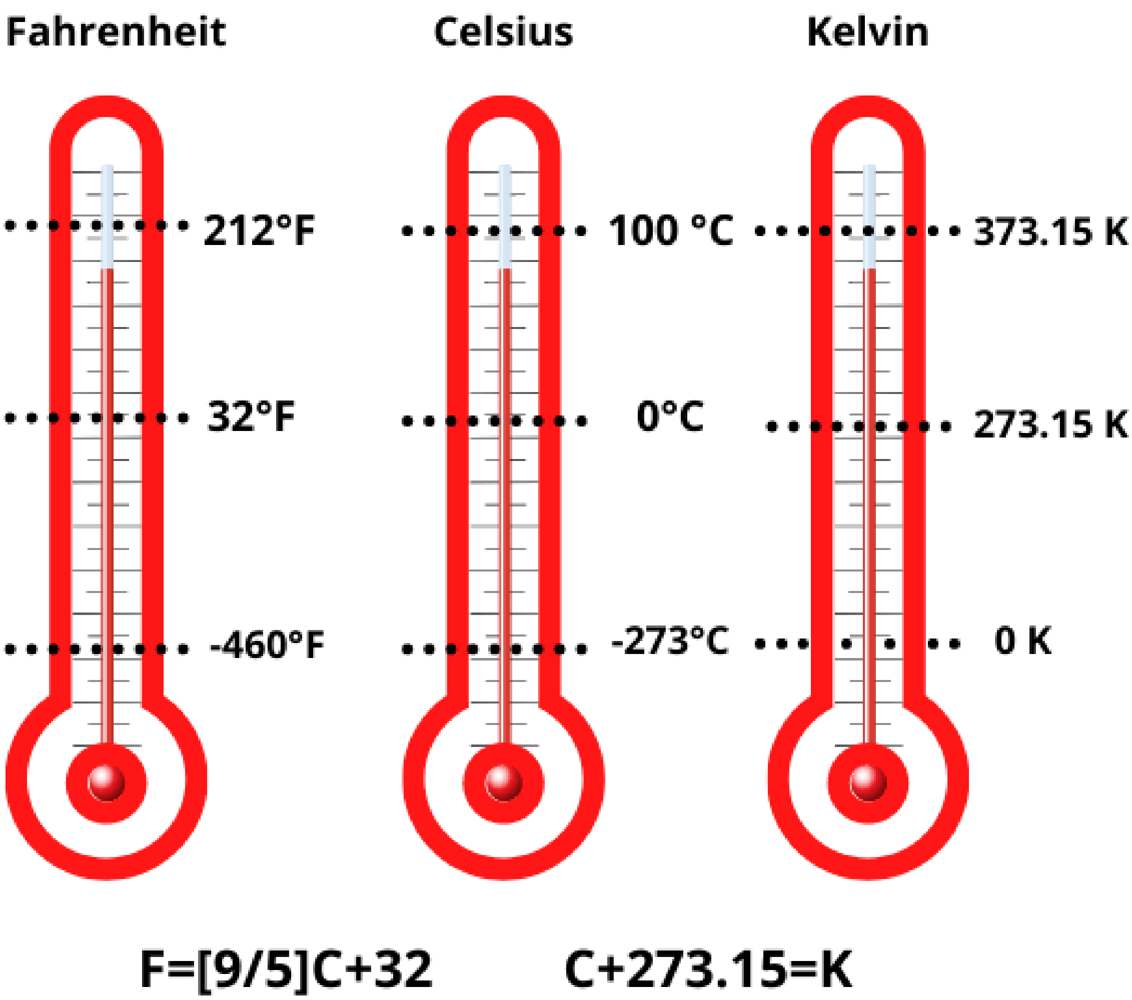
**NOTE:**

**To convert Celsius temperature to Kelvin temperatures, simply add 273.16. The temperature of 0.0 K is known as the ABSOLUTE ZERO, the lowest temperature which can be obtained.**

**Convert temperatures between kelvin and degrees Celsius.**

$$T \text{ (in K)} = \theta \text{ (in °C)} + 273$$

# TEMPERATURE SCALES






**The pressure and the changes in pressure of a gas in terms of the motion of its particles and their collisions with a surface**

- The pressure of a gas results from collisions between the gas particles and the walls of the container.
- Each time a gas particle hits the wall, it exerts a force on the wall.
- An increase in the number of gas particles in the container increases the frequency of collisions with the walls and therefore the pressure of the gas.
- The forces exerted by particles colliding with surfaces, create a force per unit area[pressure] on the walls of the container.

**Where the markschemes are not given in the revision notes, kindly refer to the same by refering to the question code**