Essential Pre-Uni Chemistry C1.2

A Level
C C C

Use the ideal gas equation of state to answer the following questions. In SI units, the equation is $pV = nRT$, where $R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$.

Part A Pressure of the gas at $85\,\mathrm{cm}^3$

$50\,\mathrm{cm}^3$ of gas at a pressure of $2.5\,\mathrm{atm}$ is allowed to expand slowly at constant temperature until it fills a volume of $85\,\mathrm{cm}^3$. Calculate the new pressure of the gas.

Part B Volume of gas.

$20\,\mathrm{dm}^3$ of gas at a pressure of $750\,\mathrm{torr}$ is compressed slowly at constant temperature until the pressure reaches $3.0 \times 10^5\,\mathrm{torr}$. Calculate the volume now occupied by the gas.

Part C New pressure inside.

A sealed, rigid container of air at $1.0\,\mathrm{atm}$ pressure falls in temperature from $296\,\mathrm{K}$ to $270\,\mathrm{K}$. Find the new pressure inside the container.

Part D New temperature in $^\circ\mathrm{C}$.

If the temperature of a gas measured in kelvin is doubled and the gas is initially at $17\,^\circ\mathrm{C}$, give its new temperature in $^\circ\mathrm{C}$.

Part E Temperature to explode.

A canister of gas will explode once the pressure exceeds $40\,\mathrm{atm}$. If the pressure inside is $8.0\,\mathrm{atm}$ at $20\,^{\circ}\mathrm{C}$, find the temperature at which the canister will explode.

Part F Find the new volume.

A sac of gas freely changes its volume to keep its internal pressure equal to atmospheric pressure. If the sac has a volume of $1.2\,\mathrm{m}^3$ at $-10\,^{\circ}\mathrm{C}$ and then warms up to $17\,^{\circ}\mathrm{C}$ with no change in pressure, find its new volume.

Essential Pre-Uni Chemistry C1.4

A Level
P P P

Use the ideal gas equation of state to answer the following questions. In SI units, the equation is $pV = nRT$, where $R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$.

A gas cylinder is being filled with argon gas. The gas cylinder has a volume of $24\,\mathrm{dm^3}$ and holds $1\,\mathrm{mol}$ of gas at room temperature and pressure.

Part A Amount of gas

Calculate the amount of gas (in moles) which must be added to raise the pressure in the cylinder from $1\,\mathrm{atm}$ to $250\,\mathrm{atm}$. Assume that the volume is constant. Give your answer to 3 significant figures.

Part B New pressure

If the gas cylinder in Part A contains a pressure of $250\,\mathrm{atm}$ at $20\,^\circ\mathrm{C}$, and is caught in a fire, so that its temperature is raised to $350\,^\circ\mathrm{C}$, calculate the new pressure inside the cylinder. Give your answer to 3 significant figures.

Essential Pre-Uni Chemistry C1.7

A Level

C C C

Use the ideal gas equation of state to answer this question. In SI units, the equation is $pV = nRT$, where $R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$.

When $2.0\,\mathrm{moles}$ of a gas mixture at $1\,\mathrm{atm}$ and $296\,\mathrm{K}$ is compressed to half its original volume, the temperature rises to $312\,\mathrm{K}$ and the pressure rises to $1.7\,\mathrm{atm}$. Some of the gas slowly leaks out during compression.

Calculate the amount of gas present in the smaller volume.

Essential Pre-Uni Chemistry C1.8

A Level

C C C

Use the ideal gas equation of state to answer this question. In SI units, the equation is $pV = nRT$, where $R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$.

A vacuum line is lowered to a pressure of $1.3\,\mathrm{kPa}$ at $77\,\mathrm{K}$.

Give the number of molecules of gas per mm^3.

Essential Pre-Uni Chemistry C1.9

A Level
C C C

Use the ideal gas equation of state to answer the following questions. In SI units, the equation is $pV = nRT$, where $R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$.

The endothermic reaction between sodium hydrogencarbonate and ethanoic acid is used to inflate a plastic bag.

Part A Find the volume at $101\,\mathrm{kPa}$

If the gas produced is at a temperature of $13\,^{\circ}\mathrm{C}$, and $4.0\,\mathrm{g}$ of sodium hydrogencarbonate reacts with excess acid, find the volume of gas produced at a pressure of $101\,\mathrm{kPa}$.

Part B New volume

If the gas then warms up to a room temperature of $32\,^{\circ}\mathrm{C}$ with no change in pressure, find the new volume of gas.

Essential Pre-Uni Chemistry I1.2

A Level

P P P

Write balanced equations to show the equilibria represented by the following equilibrium constants, K_p.

Part A (a)

$$\frac{p\,(\mathrm{Cl})^2}{p\,(\mathrm{Cl_2})}$$

Part B (b)

$$\frac{p\,(\mathrm{SO_3})^2}{p\,(\mathrm{SO_2})^2\,p(\mathrm{O_2})}$$

Part C (c)

$$\frac{p\,(\mathrm{CO})^2\,p(\mathrm{H_2})^2}{p\,(\mathrm{CH_4})\,p(\mathrm{CO_2})}$$

Essential Pre-Uni Chemistry I1.3

A Level

Complete the following table:

TOTAL PRESSURE	MOLE FRACTION	PARTIAL PRESSURE
$1.0\,\mathrm{atm}$	0.075	(a)
$125\,\mathrm{MPa}$	4.00×10^{-7}	(b)
$4.0\,\mathrm{lb\,ft^{-2}}$	0.30	(c)
$50\,\mathrm{bar}$	(d)	$200\,\mathrm{mbar}$
$2.0\,\mathrm{GPa}$	(e)	$40\,\mathrm{kPa}$
(f)	2.5×10^{-3}	$1.4 \times 10^{4}\ \mathrm{Pa}$
(g)	$80\,\%$	$120\,\mathrm{mmHg}$

Where only one of total and partial pressure is given, use the same units for the other.

Part A (a)

Partial pressure (a)

Part B (b)

Partial Pressure (b)

Part C (c)

Partial Pressure (c)

Part D (d)

Mole Fraction (d)

Part E (e)

Mole fraction (e)

Part F (f)

Total pressure (f)

Part G (g)

Total pressure (g)

Essential Pre-Uni Chemistry I1.5

A Level

The reaction

$$\mathrm{A} + \mathrm{B} \rightleftharpoons 2\,\mathrm{C}$$

occurs in the gas phase. Its value of K_p at a temperature of $600\,\mathrm{K}$ is 2500. Each row in the table below shows possible partial pressures at equilibrium at $600\,\mathrm{K}$. Find the missing value in each row.

$p(\mathrm{A})$	$p(\mathrm{B})$	$p(\mathrm{C})$
$20\,\mathrm{kPa}$	$20\,\mathrm{kPa}$	(a)
$1.00\,\mathrm{MPa}$	(b)	$100\,\mathrm{MPa}$
$12.5\,\mathrm{cm\,H_2O}$	$3.75\,\mathrm{cm\,H_2O}$	(c)
(d)	4.0×10^{6} torr	1.60×10^{8} torr
8.0×10^{-4} atm	5.0×10^{-4} atm	(e)

Use the same units for your answers as those used in that row of the table.

Part A (a)

Partial pressure (a)

Part B (b)

Partial pressure (b)

Part C (c)

Partial pressure (c)

Part D (d)

Partial pressure (d)

Part E (e)

Partial pressure (e)

Essential Pre-Uni Chemistry I1.6

Further A

The reaction

$$\mathrm{A} + \mathrm{B} \rightleftharpoons 2\,\mathrm{C}$$

occurs in the gas phase. Its value of K_p at a temperature of $600\,\mathrm{K}$ is 2500.

The table below shows initial pressures before equilibration at $600\,\mathrm{K}$. Calculate the equilibrium pressures in each case. Assume that the total gas pressure is kept constant.

Initial $p(\mathrm{A})$	Initial $p(\mathrm{B})$	Initial $p(\mathrm{C})$	Equilibrium $p(\mathrm{A})$	Equilibrium $p(\mathrm{B})$	Equilibrium $p(\mathrm{C})$
$10.0\,\mathrm{atm}$	$10.0\,\mathrm{atm}$	$0.0\,\mathrm{atm}$	(a)	(b)	(c)
$0.0\,\mathrm{MPa}$	$0.0\,\mathrm{MPa}$	$12.0\,\mathrm{MPa}$	(d)	(e)	(f)
$250.0\,\mathrm{bar}$	$250.0\,\mathrm{bar}$	$0.0\,\mathrm{bar}$	(g)	(h)	(i)
$0.00\,\mathrm{psi}$	$0.00\,\mathrm{psi}$	$2400.00\,\mathrm{psi}$	(j)	(k)	(l)

Give your answers in the same units as those used in that row.

Part A (a)

Equilibrium pressure (a). Give your answer to 3 significant figures.

Part B (b)

Equilibrium pressure (b). Give your answer to 3 significant figures.

Part C (c)

Equilibrium pressure (c). Give your answer to 3 significant figures.

Part D (d)

Equilibrium pressure (d). Give your answer to 3 significant figures.

Part E (e)

Equilibrium pressure (e). Give your answer to 3 significant figures.

Part F (f)

Equilibrium pressure (f). Give your answer to 3 significant figures.

Part G (g)

Equilibrium pressure (g). Give your answer to 4 significant figures.

Part H (h)

Equilibrium pressure (h). Give your answer to 4 significant figures.

Part I (i)

Equilibrium pressure (i). Give your answer to 4 significant figures.

Part J (j)

Equilibrium pressure (j). Give your answer to 4 significant figures.

Part K (k)

Equilibrium pressure (k). Give your answer to 4 significant figures.

Part L (l)

Equilibrium pressure (l). Give your answer to 4 significant figures.

Essential Pre-Uni Chemistry I1.8

A Level

The reaction

$$\mathrm{CH_4 + H_2O \rightleftharpoons CO + 3\,H_2}$$

has an equilibrium constant, K_p, of $150.5\,\mathrm{Pa}^2$ at a temperature of $1073\,\mathrm{K}$. [**1**]

$$K_p = \frac{p\,(\mathrm{CO})p(\mathrm{H_2})^3}{p\,(\mathrm{CH_4})p(\mathrm{H_2O})}$$

Part A (a)

If the partial pressures at equilibrium are $p(\mathrm{CH_4}) = 20.0\,\mathrm{kPa}$, $p(\mathrm{H_2O}) = 20.0\,\mathrm{kPa}$ and $p(\mathrm{CO}) = 50.0\,\mathrm{kPa}$, find the partial pressure of hydrogen at equilibrium.

Part B (b)

If equal amounts of methane and steam are mixed and allowed to reach equilibrium, and the partial pressures $p(\mathrm{CO}) = 40.0\,\mathrm{kPa}$ and $p(\mathrm{H_2}) = 120\,\mathrm{kPa}$, find the partial pressure of methane at equilibrium.

Part C (c)

Once the gases have reached equilibrium, the total pressure is suddenly doubled by the engineer. Will the following increase, decrease or stay the same as the system reaches a new equilibrium?

K_p

- increase
- stay the same
- decrease

Mole fraction of CO

- increase
- stay the same
- decrease

Mole fraction of $\mathrm{CH_4}$

- increase
- stay the same
- decrease

$p(\mathrm{H_2O})$

- increase
- stay the same
- decrease

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[1]

$$K_p = \frac{p\,(\mathrm{CO})p(\mathrm{H_2})^3}{p\,(\mathrm{CH_4})p(\mathrm{H_2O})}$$

[1] Charles O. Hawk et al, Ind. Eng. Chem., 1932, **24** (1), pp23-27