Marks 3

- What are allotropes? Give an example of a pair of allotropes involving carbon and a second example of a pair not involving carbon.

Allotropes are different molecular forms of the same element. Examples include graphite, diamond and buckminsterfullerene for carbon, white and red phosphorus and O_2 and O_3 for oxygen.

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- The following data were obtained for the reaction between gaseous nitric oxide and chlorine at 1400 K.

$$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$$

EXPERIMENT NUMBER	INITIAL [NO] (mol L^{-1})	INITIAL [Cl_2] (mol L^{-1})	INITIAL REACTION RATE (mol L^{-1} s^{-1})
1	0.10	0.10	0.18
2	0.10	0.20	0.36
3	0.20	0.10	0.72

Deduce the rate law for this reaction and calculate the value of the rate constant.

RATE LAW

In experiments 1 and 2, [NO] is kept constant. Doubling [Cl_2] doubles the rate so the reaction is first order with respect to [Cl_2].

In experiments 1 and 3, [Cl_2] is kept constant. Doubling [NO] leads to the rate increasing by a factor of four so the reaction is second order with respect to [NO].

Therefore:

$$\text{rate} \propto [NO]^2[Cl_2]$$

$$\text{rate} = k[NO]^2[Cl_2]$$

Answer: $\text{rate} = k[NO]^2[Cl_2]$

RATE CONSTANT

From experiment 1 and the rate law,

$$\text{rate} = k[NO]^2[Cl_2]$$

$$k = \frac{\text{rate}}{[NO]^2[Cl_2]} =$$

$$= \frac{(0.18\,\text{mol}\,L^{-1}\,s^{-1})}{(0.10\,\text{mol}\,L^{-1})^2(0.10\,\text{mol}\,L^{-1})}$$

$$k = 180\ \text{mol}^{-2}\ L^2\ s^{-1}$$

The units can be deduced from the rate law and the units of the rate (mol L^{-1} s^{-1}) and the concentrations (mol L^{-1}):

$$\text{units of } k = \frac{\text{mol}\,L^{-1}\,s^{-1}}{(\text{mol}\,L^{-1})^2(\text{mol}\,L^{-1})}$$

units of k are $\text{mol}^{-2}\ L^2\ s^{-1}$

Answer: $k = 180\ \text{mol}^{-2}\ L^2\ s^{-1}$