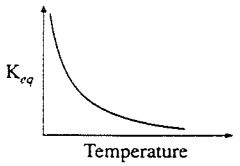
Answers

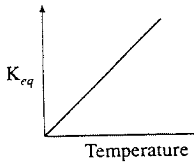
CHEMISTRY 12
Unit 2: CHEMICAL EQUILIBRIUM
LeCHATELIER'S PRINCIPLE

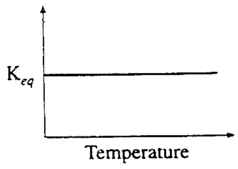
Name: ____________
Date: ____________
Section: ________

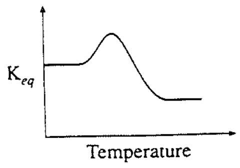
GRAPH - O - RAMA!

1. The relationship between K_{eq} and temperature for an exothermic reaction is represented by

[✓ A.]


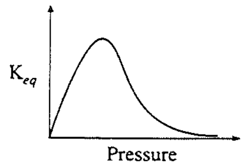
B.


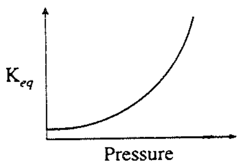
C.


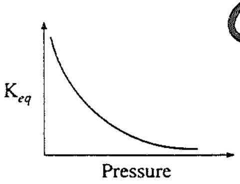
D.


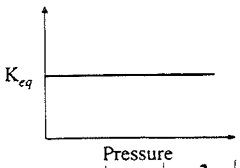
Exo. reaction: if temp ↓ then K ↑

2. The relationship between K_{eq} and the pressure of a gaseous equilibrium at constant temperature can be described by

A.


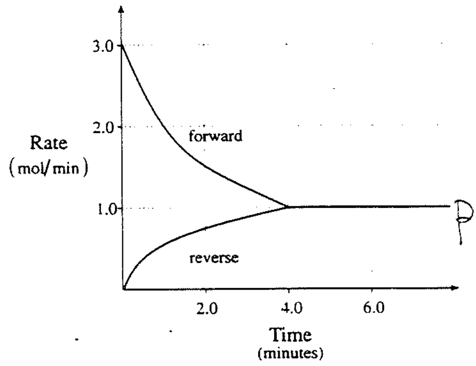
B.


C.


[✓ D.]


temp. constant ∴ K can not change

3. Consider the following graph:



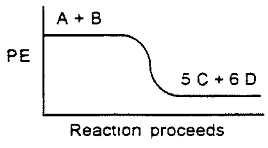
plateau at 1.0 mol/min.

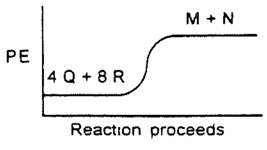
When equilibrium is reached, the rate of the forward reaction is

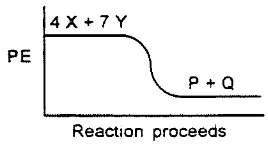
A. 0.00 mol/min
B. 0.25 mol/min
[✓ C.] 1.0 mol/min
D. 3.0 mol/min

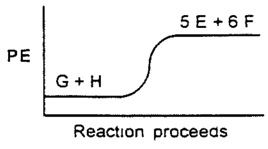
4. In each of the following, decide
i) which side is favoured by the tendency to minimum enthalpy; that is, which side of the reaction has the lower energy.
ii) which side is favoured by the tendency to maximum entropy; that is, which side of the reaction has the more random species.
iii) whether the reaction will be
- a spontaneous reaction which goes to completion ("GOES 100%"), or
- a non-spontaneous reaction in which NO products are formed ("WON'T OCCUR"), or
- a spontaneous equilibrium reaction in which the tendency to minimum enthalpy will be balanced by an opposing tendency to maximum entropy ("EQUILIBRIUM").

Note: in parts (a) to (d) all the species are GASES

a)


b)


c)


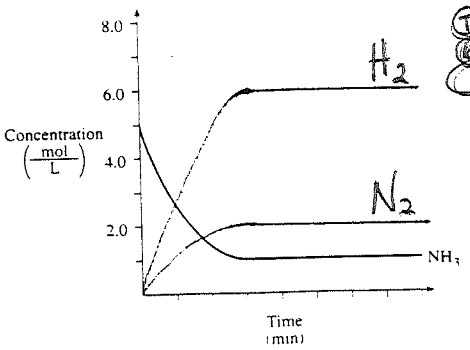
d)


e) $H_2SO_4(l) + H_2O(l) \longrightarrow H_2SO_4(aq) + 150\ kJ$
f) $C_2H_6(g) \longrightarrow C_2H_2(g) + 2H_2(g)$; $\Delta H = 311\ kJ$
g) $C_2H_2(g) + Ca(OH)_2(aq) \longrightarrow CaC_2(s) + 2H_2O(l)$; $\Delta H = 183\ kJ$
h) $2C(s) + O_2(g) \longrightarrow 2CO(g)$; $\Delta H = -221\ kJ$

		rxn
a) → PRODUCTS ΔH	→ PRODUCTS ΔS	100% forward
b) ← REACTANTS ΔH	← REACTANTS ΔS	does not occur
c) → PRODUCTS ΔH	← REACTANTS ΔS	an equil.
d) ← REACTANTS ΔH	→ PRODUCTS ΔS	an equil.
e) → PRODUCTS ΔH	→ PRODUCTS ΔS	100%
f) ← REACTANTS ΔH	→ PRODUCTS ΔS	an equil.
g) ← REACTANTS ΔH	← REACTANTS ΔS	won't occur
h) → PRODUCTS ΔH	→ PRODUCTS ΔS	100%

5. Consider the following equilibrium system:

A 1.00 L container is filled with 5.0 mol NH_3 and the system proceeds to equilibrium as indicated by the graph.



$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} + energy$
I: $\boxed{5.0M}$
C: +2.0 +6.0 −4.0
E: 2.0 6.0 $\boxed{1.0M}$

a) Draw and label the graph for N_2 and H_2. **(2 marks)**

- See ICE calc above
- Graph Equilibrium concentration as plateau

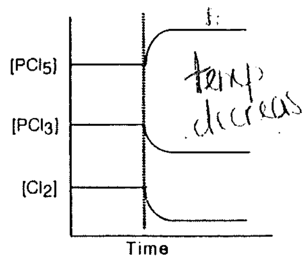
b) Calculate the K_{eq} for $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$. **(2 marks)**

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(1.0)^2}{(2.0)(6.0)^3} = 2.3\times10^{-3}$$

6. Interpret the following graphs in terms of the changes which must have been imposed on the equilibrium.

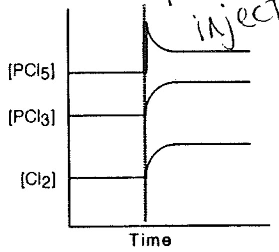
The equilibrium is: $PCl_5(g) + 92.5\ kJ \rightleftharpoons PCl_3(g) + Cl_2(g)$.

a)



temp decrease

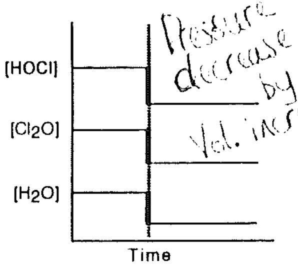
b)



$PCl_5(g)$ injected

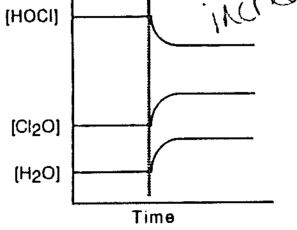
7. The equilibrium is: $H_2O(g) + Cl_2O(g) \rightleftharpoons 2\ HOCl(g) + 70\ kJ$.

a)



Pressure decrease by Vol. increase

b)



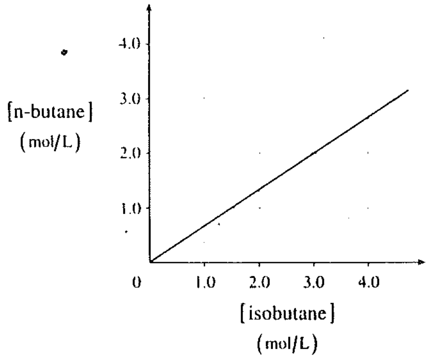
temp increase

8. Consider the graph below representing the following equilibrium:

$$CH_3CH_2CH_2CH_{3(g)} \rightleftarrows CH_3CH(CH_3)_{2(g)}$$

n-butane isobutane

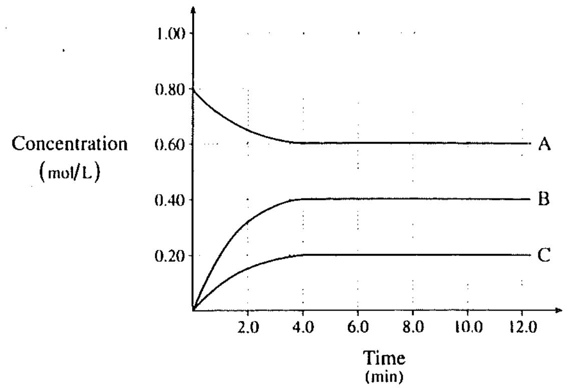
Data for the graph was obtained from various equilibrium mixtures.



Calculate the value of K_{eq} for the equilibrium. **(2 marks)**

$$K = \frac{[\text{isobutane}]}{[\text{n-butane}]} = \frac{3.0}{2.0} = 1.5$$

9. Consider the following diagram for a chemical system containing three substances represented by A, B and C:



a) What feature of the graph indicates that the system reaches equilibrium? **(1 mark)**

the plateau in A, B, and C suggest that the conc. of each becomes a constant ∴ equil.

b) Write a balanced equation for the equilibrium reaction. **(2 marks)**

A↓ as B↑ and C↑

	A	B	C
Ⓘ	$\boxed{.80}$		
Ⓡ	−.2	+.4	+.2
Ⓔ	$\boxed{.60}$	$\boxed{.40}$	$\boxed{.20}$

All data from above graph.

$\boxed{A \rightleftharpoons 2B + C}$

from mole ratio in Ⓡ line

c) Calculate K_{eq} at equilibrium. **(2 marks)**

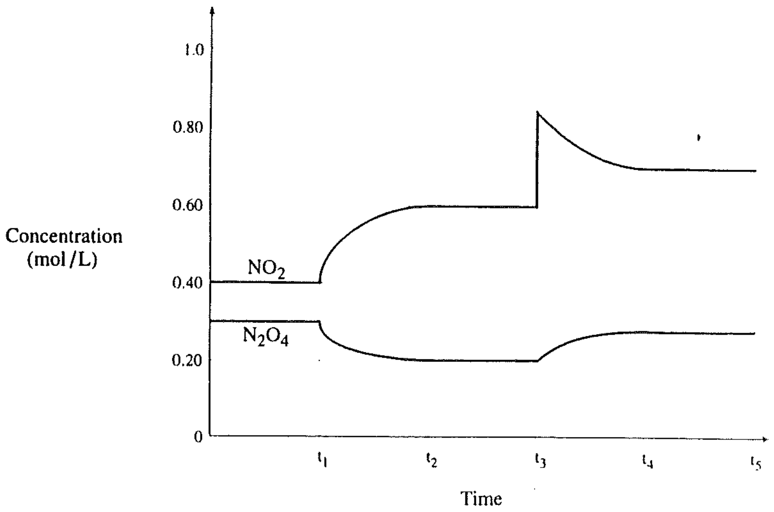
$$K = \frac{[B]^2[C]}{[A]}$$

$$= \frac{(.40)^2(.20)}{(.60)}$$

$$= .053$$

10. Consider the following graph for the reaction:

$$\text{energy} + N_2O_{4(g)} \rightleftarrows 2NO_{2(g)}$$



a) What is the stress imposed at time t_1 ? **(1 mar**

$$\text{temp. increase: } \underset{\downarrow}{N_2O_4} + \underset{\Uparrow}{kJ} \underset{\rightarrow}{\rightleftarrows} \underset{\uparrow}{2NO_2}$$

b) What is the stress imposed at time t_3 ? **(1 mark**

NO$_2$ added: ↑ ← $\overset{\downarrow}{\Uparrow}$

c) Calculate K_{eq} for the equilibrium between t_2 and t_3. **(2 marks**

$$K = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(.60)^2}{(.20)} = 1.8$$