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## EChemTest - Physical Chemistry 3

Welcome ...

1 of 20

The pressure inside a container is reduced to  $10^{-9}$  Torr, at 298.15 K, by means of a vacuum device. Calculate the number of molecules per unit volume remaining in the evacuated container.

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- ☐  $3.2 \cdot 10^6 \text{ molecules} \cdot \text{cm}^{-3}$
- ☐  $5.4 \cdot 10^{-17} \text{ mol} \cdot \text{m}^{-3}$
- ☐  $3.2 \cdot 10^{13} \text{ molecules} \cdot \text{cm}^{-3}$
- ☐  $5.4 \cdot 10^{-14} \text{ mol}$
- ☐  $3.2 \cdot 10^{11} \text{ molecules} \cdot \text{cm}^{-3}$

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If an organic acid AH is distributed between water (1) and a non polar organic solvent (2), which **two** of the following are correct ?

$\mu^*_{\text{AH}}$  denotes the chemical potential of the pure AH.

- ☐  $\mu^*_{\text{HA}}(1) = \mu^*_{\text{HA}}(2)$
- ☐  $\mu^*_{\text{HA}}(1) + \mu^*_{\text{HA}}(2) = \mu^*_{\text{AH}}$
- ☐  $\mu^*_{\text{A}^-}(1) = \mu^*_{\text{H}^+}(1)$
- ☐  $\mu^*_{\text{HA}}(1) + \mu^*_{\text{AH}}(2) = \mu^*_{\text{A}^-}(1) + \mu^*_{\text{H}^+}(1)$
- ☐  $\mu^*_{\text{HA}}(2) = \mu^*_{\text{A}^-}(1) + \mu^*_{\text{H}^+}(1)$
- 

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Derive an expression for the vapour pressure,  $P$ , of a solution as a function of the solute mole fraction,  $x_2$ , when the solute obeys Raoult's law.

Data:

$P^*_1$  is the vapour pressure of pure component 1

$P^*_2$  is the vapour pressure of pure component 2

- ☐  $P = P^*_1 + (P^*_2 - P^*_1) \cdot x_1$
- ☐  $P = P^*_1 \cdot x_1 + P^*_2 \cdot x_2$
- ☐  $P = P^*_1 + (P^*_1 - P^*_2) \cdot x_2$
- ☐  $P = P^*_1 + (P^*_2 - P^*_1) \cdot x_2$
- ☐  $P = P^*_1 \cdot x_2 + P^*_1 \cdot (1 - x_2)$
- 

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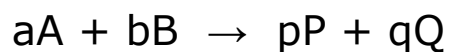
Suppose you have to neutralize one liter of a 0.1 molar solution of acetic acid (a weak acid having only 1.3% of its molecules dissociated in this solution), how much sodium hydroxide will you need?

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- ☐ Less than 0.1 mol
  - ☐ 0.1 mol
  - ☐ More than 0.1 mol
- 

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Given the reaction



if  $n_A$  is the amount of substance of species A,  $V$  is the volume of the system, the rate of disappearance  $v_A$  of species A can be written as:

- ☐  $v_A = - 1/(a \cdot V) \cdot dn_A/dt$
  - ☐  $v_A = - a/V \cdot dn_A/dt$
  - ☐  $v_A = - a \cdot V \cdot dn_A/dt$
  - ☐  $v_A = - a/t \cdot dn_A/dV$
  - ☐  $v_A = - a \cdot t \cdot dn_A/dV$
- 

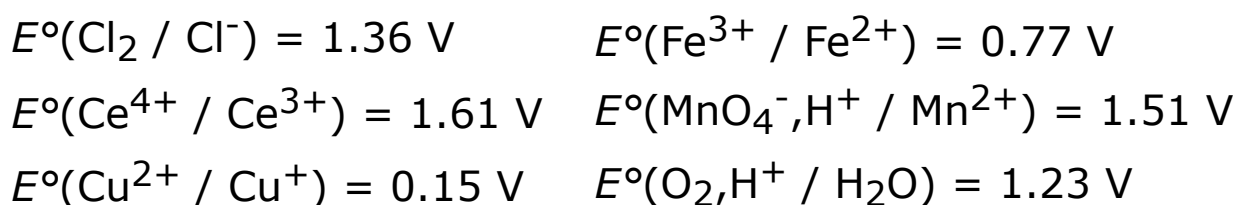
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Complete the sentence: Adding a catalyst to a chemical reaction...

- ☐ ...changes the  $\Delta_r G^\circ$  of the reaction.
  - ☐ ...changes its equilibrium constant.
  - ☐ ...changes its activation energy.
- 

7 of 20

Given the standard electrode reduction potentials at 25°C



Which **two** of the following reagents would proceed spontaneously under standard-state conditions (unit activity of the constituents)?

- ☐  $\text{Fe}^{2+}(\text{aq}) + (1/2) \text{H}_2(\text{g})$
  - ☐  $\text{Cu}^{2+}(\text{aq}) + \text{Ce}^{3+}(\text{aq})$
  - ☐  $2 \text{Ce}^{4+}(\text{aq}) + 2 \text{Cl}^-(\text{aq})$
  - ☐  $4 \text{Fe}^{3+}(\text{aq}) + 2 \text{H}_2\text{O}(\text{l})$
  - ☐  $5 \text{Fe}^{2+}(\text{aq}) + \text{MnO}_4^-(\text{aq}) + 8\text{H}^+(\text{aq})$
- 

8 of 20

How many atomic orbitals are there in the shell with  $n = 3$ ?

- ☐ 6
- ☐ 7
- ☐

3

☐ 9

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In the series of molecules  $\text{CH}_4$ ,  $\text{CH}_3\text{F}$ ,  $\text{CH}_2\text{F}_2$  and  $\text{CF}_4$ , the order of decreasing dipole moment is:

- ☐  $\text{CH}_4 = \text{CF}_4 > \text{CH}_3\text{F} > \text{CH}_2\text{F}_2$
- ☐  $\text{CF}_4 > \text{CH}_2\text{F}_2 > \text{CH}_3\text{F} > \text{CH}_4$
- ☐  $\text{CH}_2\text{F}_2 > \text{CF}_4 > \text{CH}_3\text{F} > \text{CH}_4$
- ☐  $\text{CH}_3\text{F} > \text{CH}_2\text{F}_2 > \text{CF}_4 > \text{CH}_4$
- ☐  $\text{CH}_2\text{F}_2 > \text{CH}_3\text{F} > \text{CH}_4 = \text{CF}_4$

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The nuclear spin of both  $^{31}\text{P}$  and  $^{19}\text{F}$  is  $I = 1/2$ . Which **two** of the following statements are true concerning the NMR spectra of  $\text{PF}_3$  which has  $\text{C}_{3v}$  symmetry ?

- ☐ The  $^{19}\text{F}$  spectrum is a doublet.
- ☐ The  $^{31}\text{P}$  spectrum is a singlet.
- ☐ The  $^{31}\text{P}$  spectrum is a doublet.
- ☐ The  $^{31}\text{P}$  spectrum is a quartet.
- ☐ The  $^{19}\text{F}$  spectrum is a singlet.
- ☐ The  $^{19}\text{F}$  spectrum is a quartet.

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The critical volume of  $\text{CH}_4$  is  $99 \text{ cm}^3 \cdot \text{mol}^{-1}$ . What is the approximate radius of its molecules if this gas obeys the van der Waals equation at

the critical region?

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Data:  $N_A = 6.022 \cdot 10^{23} \text{ mol}^{-1}$

nm

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12 of 20

The vapour pressure of pure benzene at 20°C is 74.66 Torr. The vapour pressure is lowered to 74.01 Torr when 2.00 g of a certain hydrocarbon with 94.4% of carbon are dissolved in 100 g of benzene at 20°C. Calculate the molecular formula of the hydrocarbon.

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☐  $\text{C}_{21}\text{H}_{15}$

- ☐  $C_{12}H_{26}$
  - ☐  $C_{16}H_{12}$
  - ☐  $C_7H_5$
  - ☐  $C_{14}H_{10}$
- 

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Consider an ideal solution formed by 3.00 mol of benzene and 2.00 mol of toluene. Calculate the ratio between the fugacity of pure benzene and the fugacity of benzene in the ideal solution. Consider all quantities at constant temperature and pressure.

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- ☐ 2.50
  - ☐ 1.00
  - ☐ 0.40
  - ☐ 0.60
  - ☐ 1.67
- 

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Consider the dissociation of nitrogen trioxide according to the reaction



If the degree of dissociation  $\alpha$  is 0.3 at  $T = 298$  K,

$P^\circ = 1 \text{ bar} = 10^5 \text{ Pa}$ , what is the standard Gibbs function in  $\text{kJ}\cdot\text{mol}^{-1}$  of this reaction?

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Data:  $R = 8.314 \text{ J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$

$\text{kJ}\cdot\text{mol}^{-1}$

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A chemical reaction at  $15^\circ\text{C}$  is complete in 3 minutes and 32 seconds. The same reaction at  $50^\circ\text{C}$ , with the same concentrations and total quantities is complete in 45 seconds. What is its activation energy?

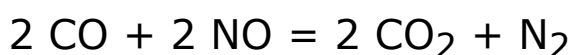
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Data:  $R = 8.314 \text{ J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$

- ☐ 39.7 kJ·mol<sup>-1</sup>
  - ☐ 34.2 kJ·mol<sup>-1</sup>
  - ☐ 44.5 kJ·mol<sup>-1</sup>
  - ☐ 28.7 kJ·mol<sup>-1</sup>
- 

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In a study case of the Pt catalysed reaction:



it was found that at low CO pressures, the reaction was first order in CO; on increasing the CO pressure at constant pressure of NO and constant  $T$ , the rate passed through a maximum, and at very high pressures, the reaction rate was inversely proportional to the pressure of CO, and the activation energy was equal to the heat of adsorption of CO. When the partial pressure of NO was much greater than that of CO, the activation energy was equal to the heat of adsorption of N<sub>2</sub>. Which **two** of the following are compatible with these observations ?

- ☐ Adsorption of NO is the rate determining step.
  - ☐ The reaction may be inhibited by one of the products.
  - ☐ The surface reaction is between CO(ads) and NO(ads).
  - ☐ The reaction  $\text{CO(ads)} + \text{O(ads)} \rightarrow \text{CO}_2\text{(ads)}$  is rate determining.
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17 of 20

Between 273 and 350 K, the potential in V of the cell



is approximately given by

$$E = 0.1213 + 1.746 \cdot 10^{-3} \cdot T - 3.26 \cdot 10^{-6} \cdot T^2$$

What is the value of the entropy of reaction  $\Delta_r S$  for the cell reaction at 298 K?

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Data:  $F = 96484 \text{ C} \cdot \text{mol}^{-1}$

- ☐ -38
- ☐ -34
- ☐ 34
- ☐ -19
- ☐ 19

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The ionization energy of sodium is 494 kJ/mol. Radiation whose wavelength is 590 nm may be used to excite a sodium atom from its ground state to a configuration  $[\text{Ne}] 3p^1$ .  
How much energy is required to ionize sodium in this excited state?

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Data:  $h = 6.63 \cdot 10^{-34} \text{ J}\cdot\text{s}$ ;  $N_A = 6.02 \cdot 10^{23} \text{ mol}^{-1}$ ;  $c = 3.00 \cdot 10^8 \text{ m/s}$

- ☐ 291 kJ/mol
  - ☐ 203 kJ/mol
  - ☐ 697 kJ/mol
  - ☐ 385 kJ/mol
  - ☐ 494 kJ/mol
- 

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The fundamental vibrational mode for  $^1\text{H}^{35}\text{Cl}$  is found at  $2988.9 \text{ cm}^{-1}$ . If the harmonic approximation is adopted, what is the force constant for  $^1\text{H}^{35}\text{Cl}$ ?

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Data:

Atomic masses:  $^1\text{H} = 1.0078$ ;  $^{35}\text{Cl} = 34.969 \text{ g/mol}$

$$c = 2.9979 \cdot 10^8 \text{ m/s}$$
$$N_A = 6.0221 \cdot 10^{23} \text{ mol}^{-1}$$

N/m

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The molar absorptivity  $\epsilon$  of chlorobenzene in n-heptane solution at 256 nm is  $\epsilon = 1.22 \cdot 10^3 \cdot \text{m}^2 \cdot \text{mol}^{-1}$ .

Calculate the concentration of chlorobenzene in a n-heptane solution if its transmission coefficient at 256 nm in a 2 cm cell is 0.296.

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 $\cdot 10^{-5} \text{ M}$ 

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