CHEMISTRY

BOOKS - CENGAGE CHEMISTRY (ENGLISH)

NCERT BASED EXERCISE

Some Basic Concepts And Mole Concept

1. Calculate the molar mass of the following:

$(i) H_2O (ii) CO_2 (iii) CH_4$

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2. Calculate the mass per cent of different elements present in sodium sulphate(Na_2SO_4).

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3. Determine the empirical formula of an oxide of iron, which has 69.9% iron and 30.1% dioxygen by mass.

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4. Calculate the amount of carbon dioxide that could be produced when

(i) 1 mole of carbon is burnt in air.

(ii) 1 mole of carbon is burnt in 16 g of dioxygen.

(iii) 2 moles of carbon are burnt in 16 g of dioxygen.

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5. Calculate the mass of sodium acetate (CH3COONa) required to make 500 mL of 0.375 molar aqueous solution. Molar mass of sodium acetate is 82.0245 g mol^{-1}.

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6. Calculate the concentration of nitric acid in moles per litre in a sample which has a density, 1.41 g mL^{-1} and the mass per cent of nitric acid in it being 69%.

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7. How much copper can be obtained from 100 g of copper sulphate $(CuSO_4)$?

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8. Determine the molecular formula of an oxide of iron, in which the mass per cent of iron and oxygen are 69.9 and 30.1, respectively.

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9. Calculate the atomic mass (average) of chlorine using the following data:

	% Natural Abundance	Molar Mass
^{35}Cl	75.77	34.9689
^{37}Cl	24.23	36.9659

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10. In three moles of ethane(C_2H_6), calculate the following:

(i) Number of moles of carbon atoms.

(ii) Number of moles of hydrogen atoms.`

(iii) Number of molecules of ethane.

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11. What is the concentration of sugar $(C_{12}H_{22}O_{11})$in molL^{-1} if its 20 g are dissolved in enough water to make a final volume up to 2L?

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12. If the density of methanol is 0.793 kgL^{-1}, what is its volume needed for making 2.5 L of its 0.25 M solution?

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13. Pressure is determined as force per unit area of the surface. The SI unit of pressure, pascal is as shown below:

$1Pa = 1Nm^{-2}$

If mass of air at sea level is 1034 g cm–2, calculate the pressure in pascal.

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14. What is the SI unit of mass? How is it defined?

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15. What do you mean by significant figures?

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16. A sample of drinking water was found to e severely contaminated with chloroform $(CHCl_3)$ supposed to e a carcinogen. The level of contamination was 15 ppm (by mass).

(i). Express this in percent by mass

(ii). Determine the molality of chloroform in the water sample.

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17. Express the following in the scientific notation:

(i) 0.0048

(ii) 234,000

(iii) 8008

(iv) 500.0

(v) 6.0012

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18. How many significant figures are present in the following?

(i) 0.0025

(ii) 208

(iii) 5005

(iv) 126,000

(v) 500.0

(vi) 2.0034

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19. Round up the following upto three significant figures:

(i) 34.216

(ii) 10.4107

(iii) 0.04597

(iv) 2808

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20. The following data are obtained when dinitrogen and dioxygen react together to form different compounds:

	Mass of dinitrogen	Mass of dioxygen
(i)	$14g$	$16g$
(ii)	$14g$	$32g$
(iii)	$28g$	$32g$
(iv)	$28g$	$80g$

(a) Which law of chemical combination is obeyed by the above experimental data? Give its statement.

(b) Fill in the blanks in the following conversions:

(i) 1 km = ... mm = ... pm

(ii) 1 mg = ... kg = ... ng

(iii) 1 mL = ... L = ... dm^3

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21. If the speed of light is $3.0 \times 108ms^{-1}$, calculate the distance covered by light in 2.00 ns.

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22. In a reaction

$A + B_2 \rightarrow AB_2$

Identify the limiting reagent, if any, in the following reaction mixtures.

a. 300atoms of $A + 200$ molecules of B

b. $2molA + 3molB$

c. 100atoms of $A + 100$ molecules of B

d. $5molA + 2.5molB$

e. $2.5molA + 5molB$

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23. Dinitrogen and dihydrogen react with each other to produce ammonia according to the following equation :

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

(i) Calculate the mass of ammonia produced if 2.00×10^3 g dinitrogen react with 1.00×10^3 g of dihydrogen.

(ii) Will any of the two reactants remain unreacted?

(iii) If yes, which one and what would be its mass?

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24. How are 0.50 mol Na_2CO_3 and 0.50 M Na_2CO_3 different?

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25. If ten volumes of dihydrogen gas react with five volumes of dioxygen gas, how many volumes of water vapour would be produced?

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26. Convert the following into basic units:

(i) 28.7 pm

(ii) 15.15 pm

(iii) 25365 mg

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27. Which one of the following will have the largest number of atoms?

(i) 1 g Au (s)

(ii) 1 g Na (s)

(iii) 1 g Li (s)

(iv) 1 g of $Cl_2(g)$

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28. Calculate the molarity of a solution of ethanol in water, in which the mole fraction of ethanol is 0.040 (assume the density of water to be one).

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29. What will be the mass of one atom of C-12 in grams?

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30. How many significant figures should be present in the answer of the following calculations?

$$\frac{2.5 \times 1.25 \times 3.5}{2.01}$$

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31. Use the data given in the following table to calculate the molar mass of naturally occuring argon isotopes:

Isotope	Isotopic molar mass	Abundance
^{36}Ar	$35.96755 gmol^{-1}$	$0.337\ \%$
^{38}Ar	$37.96272 gmol^{-1}$	$0.063\ \%$
^{40}Ar	$39.9624 gmol^{-1}$	$99.600\ \%$

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32. Calculate the number of atoms in each of the following :

(i) 52 moles of He

(ii) 52 amu of He

(iii) 52 grams of He.

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33. A welding fuel gas contains carbon and hydrogen only. Burning a small sample of it in oxygen gives 3.38 g carbon dioxide, 0.690 g of water and no other products. A volume of 10.0 L (measured at STP) of this welding gas is found to weigh 11.6 g. Calculate (i) empirical formula, (ii) molar mass of the gas, and (iii) molecular formula.

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34. Calcium carbonate reacts with aqueous HCl to give $CaCl_2$ and CO_2 according to the reaction,

$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H2O(l)$

What mass of CaCO3 is required to react completely with 25 mL of 0.75 M HCl?

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35. Chlorine is prepared in the laboratory by treating manganese dioxide (MnO_2) with aqueous hydrochloric acid according to the reaction:

$4HCl(aq) + MnO_2(s) \rightarrow 2H_2O(l) + MnCl_2(aq) + Cl_2(g).$

How many grams of HCI react with 5.0g of manganese dioxide?

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Redox Reaction

1. Assign oxidation number to the underlined elements in each of the following species:

(a)$NaH_2\underline{P}O_4$ $(b)NaH\underline{S}O_4$ $(c)H_4\underline{P}_2O_7$ $K_2\underline{Mn}O_4$

$(e)Ca\underline{O}_2$ $(f)Na\underline{B}H_4$ $(g)H_2\underline{S}_2O_7$ $(h)KAl(\underline{S}O_4)_2.12H_2O$

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2. What are the oxidation number of the underlined elements in each of the following and how do you rationalise your results ?

(a)

$\underline{K}I_3 \quad (b)H_2\underline{S}_4O_6 \quad (c)\underline{Fe}_3O_4 \quad (d)\underline{C}H_3\underline{C}H_2OH \quad (e)\underline{C}H_3\underline{C}OOH$

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3. Justify that the following reactions are redox reactions:

(a) CuO(s) + $H_2(g) \rightarrow Cu(s) + H_2O(g)$

(b) $Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$

(c) $4BCl_3(g) + 3LiAlH_4(s) \rightarrow 2B_2H_6(g) + 3LiCl(s) + 3AlCl_3(s)$

(d) $2K(s) + F_2(g) \rightarrow 2K^+F^-(s)$

(e) $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

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4. Fluorine reacts with ice and results in the change:

$H_2O(s) + F_2(g) \rightarrow HF(g) + HOF(g)$

Justify that this reaction is a redox reaction .

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5. Calculate the oxidation number of sulphur , chromium and nitrogen in $H_2SO_5, Cr_2O_7^{2-}$ and NO_3^- . Suggest structure of these compounds . Count for the fallacy .

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6. Write the formula for the following compounds:

(a) Mercury (II) chloride (b) Nickle (II) sulphate

(c) Tin (IV) oxide (d) Thallium (I) sulphate

(e) Iron (III) sulphate (f) Chromium(III) oxide

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7. Suggest a list of the substances where carbon can exhibit oxidation states from –4 to +4 and nitrogen from –3 to +5.

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8. While sulphur dioxide and hydrogen peroxide can act as oxidising as well as reducing agents in their reactions, ozone and nitric acid act only as oxidants. Why ?

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9. Consider the reactions :

(a) $6CO_2(g) + 6H_2O(1) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

(b) $O_3(g) + H_2O_2(1) + 2O_2(g)$

Why it is more appropriate to write these reactions as :

(a) $6CO_2(g) + 12H_2O(1) \rightarrow C_6H_{12}O_6(aq) + 6H_2(1) + 6O_2(g)$

(b) $O_3(g) + H_2O_2(1) \rightarrow H_2(1) + O_2(g) + O_2(g)$

Also suggest a technique to investigate the path of the above (a) and (b) redox reactions .

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10. The compound AgF_2 is unstable compound. However, if formed, the compound acts as a very strong oxidising agent. Why ?

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11. Whenever a reaction between an oxidising agent and a reducing agent is carried out, a compound of lower oxidation state is formed if the reducing agent is in excess and a compound of higher oxidation state is formed if the oxidising agent is in excess. Justify this statement giving three illustrations.

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12. How do you account for the following observations ?

Though alkaline potassium permanganate and acidic potassium permanganate both are used as oxidants, yet in the manufacture of benzoic acid from toluene we use alcoholic potassium permanganate as an oxidant. Why? Write a balanced redox equation for the reaction.

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13. Identify the substance oxidised and reduced, oxidising agent and reducing agent for each of the following reactions

(a) $2AgBr(s) \rightarrow C_6H_6O_2(aq) \rightarrow 2Ag(s) + 2HBr(aq) + C_6H_4O_2(aq)$

(b)

$HCHO(l) + 2\left[Ag(NH_3)_2\right]^+(aq) + 3OH^-(aq) \rightarrow 2Ag(s) + HCOO^-(aq$

(c)

$HCHO(l) + 2Cu^{2+}(aq) + 5OH^-(aq) \rightarrow Cu_2O(s) + HCOO^-(aq) + 3H$

(d) $N_2H_4(l) + 2H_2O_2(l) \rightarrow N_2(g) + 4H_2O(l)$

$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$

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14. Consider the reactions :

$2S_2O_3^{2-}(aq)I_2(s) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$

$S_2O_3^{2-}(aq) + 2Br_2(1) + 5H_2O(1) \rightarrow 2SO_4^{2-}(aq) + 4Br^-(aq) + 10H^+(a$

Why does the same reductant , thiosulphate react differently with iodine and bromine ?

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15. Justify giving reactions that among halogens, fluorine is the best oxidant and among hydrohalic compounds, hydroiodic acid is the best reductant.

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16. Why does the following reaction occur ?

$XeO_6^{4-}(aq) + 2F^-(aq) + 6H^+(aq) \rightarrow XeO_3(g) + F_2(g) + 3H_2O(1)$

What conclusion about the compound Na_4XeO_6 (of which XeO_6^{4-} is a part) can be drawn from the reaction.

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17. Consider the reactions :

(a)

$H_3PO_2(aq) + 4AgNO_3(aq) + 2H_2O(1) \rightarrow H_3PO_4(aq) + 4Ag(s) + 4HN$

(b)

$H_3PO_2(aq) + 2CuSO_4(aq) + 2H_2O(1) \rightarrow H_3PO_4(aq) + 2Cu(s) + H_2SO$

(c)

$C_6H_5CHO(1) + 2\left[Ag(NH_3)_2\right]^+(aq) + 3OH^-(aq) \rightarrow C_6H_5COO^-(aq) +$

(d) $C_6H_5CHO(1) + 2Cu^{2+}(aq) + 5OH^-(aq) \rightarrow$ No change observed

.

What inference do you draw about the behaviour of Ag^+ and Cu^{2+} from these reactions ?

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18. Balance the following redox reactions by ion-electron method.

$MnO_4^-(aq) + I^-(aq) \rightarrow MnO_2(s) + I_2(s)$ (in basic medium)

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19. Balance the following equations in basic medium by ion electron method and oxidation number method and identify the oxidising agent and the reducing agent.

$P_4(s) + OH^-(aq) \rightarrow PH_3(g) + H_2PO_2^-(aq)$

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20. What sorts of informations you can draw from the following reaction ?

$(CN)_2(g) + 2OH^-(aq) \rightarrow CN^-(aq) + CNO^-(aq) + H_2O(1)$

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21. Mn^{3+} ions are unstable in solution and undergo disproportionation to give Mn^{2+}, MnO_2 and H^+ ions. What will be the balanced equation for the reaction ?

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22. Consider the elements :

Cs ,Ne , I and F

(a) Identify the element that exhibits only negative oxidation state.

(b) Identify the element that exhibits only postive oxidation state.

(c) Identify the element that exhibits both positive and negative oxidation states.

(d) Identify the element which exhibits neither the negative nor does the positive oxidation state.

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23. Chlorine is used to purify drinking water. Excess of chlorine is harmful. The excess of chlorine is removed by treating with sulphur dioxide. Present a balanced equation for this redox change taking place in water.

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24. Refer to the periodic table given in your book and now answer the following questions:

(a) Select the possible non metals that can show disproportionation reaction.

(b) Select three metals that can show disproportionation reaction.

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25. In Ostwald's process for the manufacture of nitric acid, the first step involves the oxidation of ammonia gas by oxygen gas to give nitric oxide gas and steam. What is the maximum weight of nitric oxide that can be obtained starting only with 10.00 g. of ammonia and 20.00 g of oxygen ?

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Atomic Structure

1. calculate the number of electrons which will together weigh one gram.

(ii) calculate the mass and charge of one mole of electrons .

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2. calculate the total number of electrons present in one mole of methane.

(ii) find (a) the total number and (b) the total mass of neutrons is $7mgof^{14}C.$

(Assume that mass of neutron = $1.675 \times 10^{-27}kg\big)$.

(iii) find (a) the total number and (b) the total mas of protons in 34 mg of NH_3 at STP .

will the answer change if the temperature and pressure are changed ?

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3. how many neutrons and protons are there in the following nuclei ?

$._6^{13}C,_8^{16}O,_{12}^{24}Mg,_{26}^{56}Fe,_{38}^{88}Sr$

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4. write the complete symbol for the atom with the given atomic number (Z) and atomic mass (A).

(i) Z=17 , A=35.

(ii) Z= 92 , A = 233.

(iii) Z= 4 , A= 9.

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5. Yellow ligth emitted from a sodium lamp has a wavelength (λ) of 580 nm. Calculate the frequency (v) and wavenumber $(\bar{v})$ of the yellow light .

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6. find energy of each of the photons which

(i) correspond to light of frequency $3 \times 10^{15} Hz$.

(ii) have wavelength of 0.50 A.

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7. calculate the wavelength frequency and wavenumber of a light wave whose period is $2.0 \times 10^{-10} s$.

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8. what is the number of photons of light with a wavelength of 4000 pm that provide 1 J of energy ?

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9. A photon of wavelength 4×10^{-7} m strikes on metal surface. The work funcation of the metal being 2.13eV. Calculate (i) the energy of the photon (eV) . (ii) the kinetic energy of the emission, and (ii) the velcoity of the photoelectron $\left(1eV = 1.6020 \times 10^{-19} J\right)$

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10. Electromagnetic radiation of wavelength 242 nm is just sufficient to ionise the sodium atom . Calculate the ionisation the ionisation energy of sodium in KJmol^{-1} .

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11. A 25 watt bulb emits monochromatic yellow light of wavelength of $0.57\mu m$ calculate the rate of emission o0f quanta per second.

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12. electrons are emitted with zero velocity from a metal surface when it is exposed to radiation of wavelength 6800 A . Calculate thrshold frequency (v_0) and work funcation (W_0) of the metal.

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13. what is the wavelength of light emitted when the electron in a hydrogen atom undergoes transition from an energy level with n=4 to and energy level with n=2 ?

$(e) \quad n = 3 \quad l = 3 \quad m_1 = -3 \quad m_s = +1/2$

$(f) \quad n = 3 \quad l = 1 \quad m_1 = 0 \quad m_s = +1/2$

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14. how much energy is required to ionise a H atom if the electron occupies n=5 orbitl? Compare answer with the ionization enthalpy of H atom (energy required to remove the electron from n=1 orbit)

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15. What is the maximum number of emission lines when the excited electron of a hydrogen atom in n = 6 drops to ground state?

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16. the energy associated with the first orbit in the hydrogen atom is $-2.18 \times 10^{-18} J \ \text{atom}^{-1}$. What is the energy associated with the fifth orbit ?

(ii) calculate the radius of Bohr's fifth orbit for hydrogen atom .

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17. calculate the wavenumber for the longest wavelength transition in the balmer series of atomic hydrogen .

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18. what is the energy in joules, required to shift the electron of the hydrogen atom from the first bohr orbit to the fifth bohr orbit and what is the wavelenght of the light emitted when the electron returns to the ground state? The ground state electron energy is -2.18×10^{-11} ergs.

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19. The electron energy in hydrogen atom is given by $E_n = -\frac{2.18 \times 10^{-18}}{n^2} J$. Calculate the energy required to remove an electron completely from the n=2 orbit. What is the longest wavelength of light in cm that can be used to cause this transition?

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20. calculate the wavelength of an electron moving with a velcoity of $2.05 \times 10^7 ms^{-1}$.]

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21. the mass of an electron is 9.1×10^{-31} kg . If its K.E. is $3.0 \times 10^{-25} J$. Calculate its wavelength .

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22. which of the following are isoelectronic species i.e. those having the same number of electrons ?

$Na^+, K^+, Mg^{2+}, Ca^{2+}, S^{2-}, Ar.$

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23. write the electronic configurations of the following ions : $(a)H^-(b)Na^+(c)O^{2-}, (d)F^-$

(ii) write are the atomic numbers of elements whose outermost electrons are respersented by $(a)3s^1(b)2p^3$ and $(c)3p^5$?

(iii) which atoms are indicated by the following configurations ?

$[He]2s^1(b)[Ne]3s^23p^3(c).\ [Ar]4s^23d^1$.

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24. What is the lowest value of n that allows g orbital to exist?

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25. An electron is in one of the 3d orbitals , give the possible values of n , 1 and m_1 for this electron.

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26. an atom of an element contains 29 electrons and 35 neutrons . Dedue (i) the number of protons and (ii) the electronic configuration of the element.

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27. give the number of electrons in the species H_2^+, H_2 and O_2^+.

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28. An tomic obital has n=3 , what are the possible values of l and m_l ? (ii) List the quantum numbers $(m_l$ and $l)$ of electrons for 3d orbital .

(iii) which of the following orbitals are possible ?

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29. using s,p notations , describe the orbital with the following quantum numbers.

(a) n =1, l=0 (b) n=3 , l=1 © n=4 , l=2 (d)n=4 , l=3

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30. Explain giving reasons , which of the following sets of quantum numbers are not possible.

$(a) \quad n=0 \quad l=0 \quad m_1=0 \quad m_s=+1/2$

$(b) \quad n=1 \quad l=0 \quad m_1=0 \quad m_s=-1/2$

$(c). \quad n=1 \quad l=1 \quad m_1=0 \quad m_s=+1/2$

$(d) \quad n=2 \quad l=1 \quad m_1=0 \quad m_s=-1/2$

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31. How many electrons in an atom may have the following quantum numbers?

(a) $n = 4, m_s = -1/2$ (b) n=3 , l=0

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32. Show that the circumference of the Bohr orbit for the hydrogen atom is an integral multiple of the de Broglie wavelength associated with the electron revolving around the orbit

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33. What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition $n = 4 \rightarrow n = 2 of He^+$ spectrum?

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34. Calculate the energy required for the process

$He^+(g) \rightarrow He^{2+}(g) + e^-$

The ionization energy for the H atom in the ground state is $2.18 \times 10^{-18} J \text{atom}^{-1}$

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35. If the diameter of a carbon atom is 0.15 nm, calculate the number of carbon atoms which can be placed side by side in a straight line across length of scale of length 20 cm long.

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36. 2×10^8 atoms of carbon are arranged side by side. Calculate the radius of carbon atom if the length of this arrangement is 2.4 cm.

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37. The diameter of zinc atom is 2.6 A .Calculate (a) radius of zinc atom in pm and (b) number of atoms present in a length of 1.6 cm if the zinc atoms are arranged side by side lengthwise.

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38. A certain particle carries $2.5 \times 10^{-16} C$ of static electric charge. Calculate the number of electrons present in it.

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39. In Milikan's experiment, static electric charge on the oil drops has been obtained by shining X-rays. If the static electric charge on the oil drop is $-1.282 \times 10^{-18} C$, calculate the number of electrons present on it.

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40. In Rutherford's experiment, generally the thin foil of heavy atoms, like gold, platinum etc. have been used to be bombarded by the α-particles. If the thin foil of light atoms like aluminium etc. is used, what difference would be observed from the above results?

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41. Symbols ${}_{35}^{79}Br$ and ${}^{79}Br$ can be written, whereas symbols ${}_{79}^{35}Br$ and ${}^{35}Br$ are not acceptable. Answer briefly.

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42. An element with mass number 81 contains 31.7% more neutrons as compared to protons. Assign the atomic symbol

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43. An ion with mass number 37 possesses one unit of negative charge. If the ion contains 11.1% more neutrons than the electrons, find the symbol of the ion.

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44. An ion with mass number 56 contains 3 units of positive charge and 30.4% more neutrons than electrons. Assign the symbol to this ion.

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45. Arrange the following type of radiations in increasing order of frequency: (a) radiation from microwave oven (b) amber light from traffic signal (c). radiation from FM radio (d) cosmic rays from outer space and (e) X-rays

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46. Nitrogen laser produces a radiation at a wavelength of 337.1 nm. If the number of photons emitted is 5.6×10^{24}, calculate the power of this laser.

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47. Neon gas is generally used in the sign boards. If it emits strongly at 616 nm, calculate (a) the frequency of emission, (b) distance traveled by this radiation in 30 s (c). energy of quantum and (d) number of quanta present if it produces 2 J of energy

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48. In astronomical observations, signals observed from the distant stars are generally weak. If the photon detector receives a total of $3.15 \times 10^{-18} J$ from the radiations of 600 nm, calculate the number of photons received by the detector.

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49. Lifetimes of the molecules in the excited states are often measured by using pulsed radiation source of duration nearly in the nano second range. If the radiation source has the duration of 2 ns and the number of photons emitted during the pulse source is 2.5×10^{15}, calculate the energy of the source

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50. The longest wavelenght doublet absorption transition is observed at 589 and 589.6 nm. Energy difference between two excited states is

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51. The work function for caesium atom is 1.9 eV. Calculate (a) the threshold wavelength and (b) the threshold frequency of the radiation. If the caesium element is irradiated with a wavelength 500 nm, calculate the kinetic energy and the velocity of the ejected photoelectron

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52. Following results are observed when sodium metal is irradiated with different wavelength. Calculate (a) threshold wavelength and (b) Planck's constant

$\lambda(nm)$	500	450	400
$v \times 10^{-5}\left(cms^{-1}\right)$	2.55	4.35	5.35

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53. The ejection of the photoelectron from the silver metal in the photoelectric effect experiment can be stopped by applying the voltage of 0.35 V when the radiation 256.7 nm is used. Calculate the work function for silver metal.

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54. If the photon of the wavelength 150 pm strikes an atom and one of its inner bound electrons is ejected out with a velocity of $1.5 \times 10^7 ms^{-1}$, calculate the energy with which it is bound to the nucleus

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55. Emission transition in the Paschen series end at orbit n=3 and start from orbit n and can be represented as $v = 3.29 \times 10^{15}(Hz)\left[1/3^2 - 1/n^2\right]$

Calculate the value of n if the transition is observed at 1285nm Find the region of the spectrum.

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56. Calculate the wavelength for the emission transition if it starts from the orbit having radius 1.3225 nm and ends at 211.6 pm. Name the series to which this transition belongs and the region of the spectrum.

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57. Dual behaviour of matter proposed by de Broglie led to the discovery of electron microscope often used for the highly magnified images of biological molecules and other type of material. If the velocity of the electron in this microscope is $1.6 \times 10^6 ms^{-1}$, calculate de Broglie wavelength associated with this electron.

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58. Similar to electron diffraction, neutron diffraction microscope is also used for the determination of the structure of molecules. If the wavelength used here is 800 pm, calculate the characteristic velocity associated with the neutron

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59. If the velocity of the electron in Bohr's first orbit is $2.19 \times 10^6 ms^{-1}$, calculate the de Broglie wavelength associated with it.

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60. The velocily associated wiih a proton moving in a potential difference of 1000 V is $4.37 \times 10^5 ms^{-1}$. If the böckey ball of mass 0.1 kg is moving with this velocity, calculate the wavelength associated with this velocity.

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61. If the position of the electron is measured within an accuracy of + 0.002 nm, calculate the uncertainty in the momentum of the electron. Suppose the momentum of the electron is $h/4\pi_m \times 0.05nm$, is there any problem in defining this value

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62. The quantum numbers of six electrons are given below. Arrange them in order of increasing energies. If any of these combination(s) has/have the same energy lists:

1. $n = 4, l = 2, m_i = -2, m_s = -1/2$

2. $n = 3, l = 2, m_l = 1, m_s = +1/2$

3. $n = 4, l = 2, m_l = -2, m_s = -1/2$

4. $n = 3, l = 2, m_i = -1, m_s = +1/2$

5. $n = 3, l = 1, m_l = -1, m_s = +1/2$

$n = 4, l = 1, m_l = 0, m_s = +1/2$

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63. The bromine atom possesses 35 electrons. It contains 6 electrons in 2p orbital, 6 electrons in 3p orbital and 5 electrons in 4p orbital. Which of these electron experiences the lowest effective nuclear charge

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64. Among the following pairs of orbitals which orbital will experience the larger effective nuclear charge? (i) 2s and 3s, (ii) 4d and 4f, (iii) 3d and 3p

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65. The unpaired electrons in Al and Si are present in 3p orbital. Which electrons will experience more effective nuclear charge from the nucleus?

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66. Indicate the number of unpaired electrons in: (a) P, (b) Si, (c). Cr, (d) Fe and (e) Kr

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67. (a) How many sub-shells are associated with n = 4? (b) How many electrons will be present in the sub-shells having m_s value of

$-1/2f$ or $n = 4$?

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68. What will be the minimum pressure required to compress 500 dm^3 of air at 1 bar to 200 dm^3 at $30^\circ C$?

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69. A vessel of 120 mL capacity contains a certain amount of gas at $35^\circ C$ and 1.2 bar pressure. The gas is transferred to another vessel of volume 180 mL at $35^\circ C$. What would be its pressure?

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70. Using the equation of state pV=nRT, show that at a given temperature density of a gas is proportional to gas pressure p.

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71. At $0^\circ C$, the density of a certain oxide of a gas at 2 bar is same as that of dinitrogen at 5 bar. What is the molecular mass of the oxide?

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72. Pressure of 1 g of an ideal gas A at $27C^\circ$ is found to be 2 bar . When 2 g of another ideal gas B is introduced in the same flask at same temperature the pressure becomes 3 bar . What would be the ratio of their molecular masses ?

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73. The drain cleaner, Drainex contains small bits of aluminum which react with caustic soda to produce dihydrogen. What volume of dihydrogen at $20^\circ C$and one bar will be released when 0.15g of aluminum reacts?

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74. What will be the pressure of the gas mixture of 3 . 2 g methane and 4 .4 g carbon dioxide contained in a 9 dm^m flask at $27.^\circ C$?

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75. What will be the pressure of the gaseous mixture when 0.5 L of H_2 at 0.8 bar and 2.0 L of dioxygen at 0.7 bar are introduced in a 1L vessel at $27^\circ C$?

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76. Density of a gas is found to be $5.46g/dm^3$ at $27.^\circ C$ and 2 bar pressure . What will be its density at STP ?

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77. 34 . 05 mL of phosphorus vapours weigh 0.0625 g at $546.^{\circ} C$ and 0.1 bar pressure . What is the molart mass of phosphorus ?

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78. A student forgot to add the reaction mixture to the round bottomed flask at $27^{\circ} C$ but instead he/she placed the flask on the flame. After a lapse of time, he realized his mistake, and using a pyrometer he found the temperature of the flask was $477^{\circ} C$. What fraction of air would have been expelled out?

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79. Calculate the temperature of 4.0 mol of a gas occupying 5 dm^3 at 3.32 bar ($R = 0.083$ bar $dm^3 K^{-1} mol^{-1}$).

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80. calculte the total number of electrons present 1.4 g of dinitrogen gas.

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81. how much time would it take to distribute on Avogadro number of wheat grains, if 10^{10} grains are distribute each second ?

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82. Calculate the total pressure in a mixture of 8 g of dioxygen and 4 g of dihydrogen confined in a vessel of 1 dm^3 at $27^\circ C$. R =0.083 bar $dm^3 K^{-1} mol^{-1}$.

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83. Pay load is defined as the difference between the mass of displaced air and the mass of the balloon Calculate the pay-load when a balloon of

radius $10m$ mass $100kg$ is filled with helium at 1.66 bar at $27^\circ C$ (Density of air $= 1.2kgm^{-3}$ and $R = 0.083$ bar dm 3 $K^{-1}mol^{-1}$) .

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84. Calculate the volume occupied by 8.8 g of CO_2 at $31.1^\circ C$ and 1 bar pressure. R= 0.083 bar L $K^{-1}mol^{-1}$.

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85. 2.9 g of a gas at $95^\circ C$ occupied the same volume as 0.184 g of dihydrogen at $17^\circ C$, at the sam e pressure. What is the molar mass of the gas?

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86. A mixture of dihydrogen and dioxygen at one bar pressure contains 20% by weight of dihydrogen. Calculate the partial pressure of

dihydrogen.

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87. What would be the SI unit for the quantity PV^2T^2/n?

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88. In terms of Charles' law explain why $-273^\circ C$is the lowest possible temperature.

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89. Critical temperature for carbon dioxide and methane are 31.1 $^\circ C$ and -81.9 $^\circ C$ respectively. Which of these has stronger intermolecular forces and why?

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90. Explain the physical significance of van der Waals parameters.

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91. A straight glass tube has two inlets X and Y at the two ends. The length of the tube is 200 cm. HCl gas through inlet X and NH_3 gas through inlet Y are allowed to enter the tube at the same time. White fumes first appear at a point Pinside the tube. Find the distance of P from X.

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92. From two identical holes, nitrogen and an unknown gas are leaked into a common vessel of $3L$ capacity for $10\ \min$, at $27^\circ C$. The resulting pressure is 4.18 bar and the mixture contains $0.4mol$ of nitrogen. What is the molar mass of the unknown gas?

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93. Equal volumes of two gases A and B diffuse through a porous pot in 20 and 10 seconds respectively if the molar mass of A be 80 find the molar mass of B .

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94. Calculate the total and average kinetic energy of $32g$ methane molecules at $27^\circ C\left(R = 8.314JK^{-1}mol^{-1}\right)$.

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Thermodynamics

1. Choose the correct answer. A thermodynamic state function is a quantity

A. used to determine heat changes

B. whose value is independent of path

C. used to detemine pressure volume work

D. whose value depends on temperature only

Answer: b

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2. For the process to occur under adiabatic conditions, the correct condition is

A. $\Delta T = 0$

B. $\Delta p = 0$

C. $q = 0$

D. $w = 0$

Answer: c

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3. The enthalpies of all elements in their standard states are

A. Unity

B. Zero

C. < 0

D. Different for each element

Answer: b

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4. ΔU° of combustion of methane is $-XkJmol^{-1}$. The value of ΔH° is

A. $= \Delta U^{\Theta}$

B. $> \Delta U^{\Theta}$

C. $< \Delta U^{\Theta}$

D. zero

Answer: c

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5. The enthalpy of combustion of methane, graphite and dihydrogen at 298 K are, $-890.3kJmol^1 - 393.5kJmol^{-1}$, and $-285.8kJmol^{-1}$ espectively. Enthalpy of formation of $CH_4(g)$ will be

A. $-74.8kJmol^{-1}$

B. $-52.27kJmol^{-1}$

C. $+74.8kJmol^{-1}$

D. $+52.26kJmol^{-1}$

Answer: a

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6. A reaction $A + B \rightarrow C + D + q$ is found to have a positive entropy change, the reaction will be:

A. possible at high temperature

B. possible only at low temperature

C. not possible at any temperature

D. possible at any temperature

Answer: d

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7. In a process, 701 J of heat is absorbed by a system and 394 J of work is done by the system. What is the change in internal energy for the process?

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8. The reaction of cyanamide, $NH_2CN(s)$, with dioxygen was carried out in a bomb calorimeter, and ΔU was found to be $-742.7kJmol^{-1}$ at 298 K. Calculate enthalpy change for the reaction at 298 K.

$$NH_2CH(g) + \frac{3}{2}O_2(g) \rightarrow N_2(g) + CO_2(g) + H_2O(1)$$

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9. Calculate the number of kJ of heat necessary to raise the temperature of 60.0 g of aluminium from $35^\circ C \text{to} 55^\circ C$. Molar heat capacity of Al is 24 J $mol^{-1}K^{-1}$.

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10. The enthalpy change on freezing of 1 mol of water at 5°C to ice at -5°C is :

(Given $\Delta_{\text{fus}}H = 6KJ\text{mol}^{-1}$ at $0^\circ C$,

$C_p(H_2O, l) = 75.3J\text{mol}^{-1}K^{-1}$,

$C_p(H_2O, S) = 36.8J\text{mol}^{-1}K^{-1}\Big)$

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11. Enthalpy of combustion of carbon to CO_2 is $-393.5kJmol^{-1}$

Calculate the heat released upon formation of 35.2 g of CO_2 from carbon and dioxygen gas.

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12. Enthalpies of formation of $CO(g).\, CO_2(g)$ and N_2O_4 are $-110,\ -393, 81$ and $9.7kJmol^{-1}$ respectively. Find the value of $\Delta_r H$ for the reaction :

$N_2O_4(g) + 3CO(g) \rightarrow N_2O(g) + 3Co_2(g)$

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13. Given

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g), \Delta_r H^{\ominus} = -92.4kJmol^{-1}$

What is the standard enthalpy of formation of NH_3 gas?

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14. Calculate the standard enthalpy of formation of $CH_3OH(l)$ from the following data

$CH_3OH(i) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(1), \Delta_r H^{\ominus} = -726kJmol^{-1}$

C(graphite) $+O_2(g) \rightarrow CO_2(g), \Delta_c H^{\ominus} = -393kJmol^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(1), \Delta(f)H^{\ominus} = -286kJmol^{-1}$

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15. Calculate the enthalpy change for the process

$CCI_4(g) \rightarrow C(g) + 4CI(g)$

and calculate bond enthalpy of C - Cl in $CCI_4(g)$.

$\Delta_{\text{vap}} H^{\ominus}(CCI_4) = 30.5kJmol^{-1}$

$\Delta_f H^{\ominus}(CCI_4) = -135.5kJmol^{-1}$

$\Delta_a(C) = 715.0kJmol^{-1}$, where $\Delta_a H^{\ominus}$ is enthalpy of atomisation

$\Delta_a H^{\ominus}(CI_2) = 242kJmol^{-1}$

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16. For an isolated system, $\Delta U = 0$, what will be ΔS?

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17. For the reaction at 298 K,

2A + B $\rightarrow$ C

$\Delta H = 400 KJ mol^{-1}$ and $\Delta S = 0.2 kJ K^{-1} mol^{-1}$

At what temperature will the reaction become spontaneous considering

ΔH and ΔS o be constant over the temperature range.

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18. For the reaction,

$2CI(g) \rightarrow CI_2(g)$, what are the signs of ΔH and ΔS ?

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19. For the reaction

$2A(g) + B(g) \rightarrow 2D(g)$

$\Delta U^{\theta} = -10.55KJ$ and $\Delta S^{\theta} = -44.1JK^{-1}$

Calculate $\Delta G^{\ominus}$ for the reaction, and predict whether the reaction may occur spontaneously

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20. The equilibrium constant for a reaction is 10. What will be the value of ΔG^{θ}?

$R = 8.314JK^{-1}mol^{-1}T = 300JK.$

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21. Comment on the thermodynamic stability of $NO_{(g)}$, given

$$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g) \quad : \quad \Delta_r H^{\theta} = 90kJmol^{-1}$$

$$NO(g) + \frac{1}{2}O_2(g) \rightarrow NO_2(g) \quad : \quad \Delta_r H^{\theta} = -74kJmol^{-1}$$

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22. Calculate the entropy change in surroundings when 1.00 mole of $H_2O(l)$ is formed under standard conditions.

$\Delta_f H^\circ = -286 kJ mol^{-1}$

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23. $0.562g$ of graphite kept in a bomb calorimeter in excess of oxygen at $298K$ and 1 atmospheric pressure was burnt according to the equation,

$C_{Graphite} + O_{2(g)} \rightarrow CO_{2(g)}$

durgin the reaction, temperature rises from $298K$ o $298.89K$. If the heat capacity of the calorimeter and its contents is $20.7kJ/K$, what is the enthalpy change for the above reaction at $298K$ and $1atm$?

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24. Red phosphorus reacts with liquid bromine in an exothermic reaction : $2P_{(s)} + 3Br_{2(l)} \rightarrow 2PBr_{3(g)} \quad \Delta_r H^\circ = -243kJ.$ Calculate the

enthalpy change when $2.63g$ of phosphorus with an excess of bromine in this way.

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25. A swimmer coming out from a pool is covered with a film of water weighing about $80g$. How much heat must be supplied to evaporate this water ? If latent heat of evaporation for H_2O is $40.79kJmol^{-1}$ at $100^\circ C$.

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26. With the help of thermochemical equations given below, determine $\Delta_r H^\Theta$ at $298K$ for the following reaction:

$C(\text{graphite}) + 2H_2(g) \to CH_4(g), \Delta_r H^\Theta = ?$

$C(\text{graphite}) + O_2(g) \to CH_2(g), \Delta_r H^\Theta = -393.5kJmol^{-1}$ ...(1)

$H_2(g) + 1/2O_2(g) \to H_2O(l),$

$\Delta_r H^\Theta = -285.8kJmol^{-1}$ ...(2)

$CO_2(2)(g) + 2H_2O(l) \to CH_4(g) + 2O_2(g),$

$\Delta_r H^\Theta = +890.3kJmol^{-1}$ ...(3)

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27. The combustion of $1mol$ of benzene takes place at $298K$ and $1atm.$ After combustion, $CO_2(g)$ and $H_2O(l)$ are produced and $3267.0kJ$ of heat is librated. Calculate the standard entalpy of formation, $\Delta_f H^{\Theta}$ of benzene

Given: $\Delta_f H^{\Theta} CO_2(g) = -393.5kJmol^{-1}$

$\Delta_f H^{\Theta} H_2O(l) = -285.83kJmol^{-1}.$

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28. Use the bond enthalpies listed below to estimate the enthalpy change for the reaction

$H_2(g) + Br_2(g) \rightarrow 2HBr(g)$

Given:

BE of H_2, Br_2, and HBr is 435, 192, and $372kJmol^{-1}$, respectively.

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29. Explain the following terms:

(a) System, surroundings

(b) State function

(c) Heat capacity, molar heat capacity

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30. Define the following terms:

(a) Standard enthalpy of formation

(b) Bond enthalpy

(c) Zeroth law of thermodynamics

(d) Reversible and irrversible process

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31. In what way internal energy is different from enthalpy? Explain both the terms with suitable examples.

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32. Which of the following are open, close or nearly isolated system?

(a) Human being

(b) The earth

(c) Can of tomato soup

(d) Ice-cube tray filled with water,

(e) A satellite in an orbit

(f) Coffie in a thermos flask, and

(g) Helium-filled balloon.

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33. Which of the following are state functions?

(a) Height of a hill

(b) Distance travelled in climbing the hill

(c) Energy change in climbing the hill

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34. Give the appropriate reason for the followings:

a. It is a preferable to determine a change in enthalpy than change in internal energy.

b. It is necessary to define the 'standard state.

c. It is necessary to specify the phases of the reactant and products in a thermochemical equation.

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35. (a) Calculate the energy needed to raise the temperature of $10.0g$ of iron from $25^{\circ}C$ to $500^{\circ}C$ if specific heat capacity of iron if $0.45J(.^{\circ}C)^{-1}g^{-1}$

(b) What mass of gold (of specific heat capacity $0.13J(.^{\circ}C)^{-1}g^{-1}$ can be heated can be heated through the same temperature difference when supplied with the same amount of energy as in (a) ?

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36. Standard vaporization enthalpy of benzene at its boiling point is $30.8kJmol^{-1}$, for how long would a $100W$ electric heater have to operate in order to vaporize a $100g$ sample of benzene at its boiling temperature?

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37. Use the standard enthalpies of formation and calculation the enthalpy changes accompanying the following reaction:

a. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

Given, enthalpies of formation of $CH_4, CO_2$and H_2O are $74.8kJmol^{-1}$, $-393.5kJmol^{-1}$, $-286kJmol^{-1}$ respectively.

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38. Acetic acid (ethanoic acid) and hydrochloric acid react with KOH solution. The enthalpy of neutralisation of ethanoic acis is

$-55.8kJmol^{-1}$ while that of hydrochloric acid is $-57.3kJmol^{-1}$. Can you think of how are these different?`

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39. Specific heat of $Li(s), Na(s), K(s), Rb(s)$ and $Cs(s)$ at $398K$ are $3.57, 1.23, 0.756, 0.363$ and $0.242Jg^{-1}K^{-1}$ respectively. Compute the molar heat capacity of these elements and identify any periodic trend. If there is trend, use it to predict the molar heat capacity of Fr.

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40. Calculate the enthalpy change when $2.38g$ of carbon monoxide (CO) vaporise at its normal boiling point.$\Delta H_{vap}CO = 6.04kJmol^{-1}$

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41. Propane has the structutre $H_3C - CH_2 - CH_3$. Use the average the bond enthalpies to estimate the change in the enthalpy, ΔH, for the following reaction:

$C_3H_8(g) + 5O_2(g) \rightarrow 3Co_2(g) + 4H_2O(g)$

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42. If standard enthalpy change $\Delta_r H^{\Theta} = -2.05 \times 10^3 kJmol^{-1}$ calculate the energy of oxygen-oxygen bond in O_2 molecules and compare the calculate value with the value given in the table.

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43. What is the basic difference between enthalpy of formation and enthalpy of reaction? Illustrate with suitable examples.

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44. Use standard enthalpies of formation to calculate the value of $\Delta_r H^{\Theta}$

for the reaction

$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(l) + 2SO_2(g)$

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45. Calculate the $Delat_r H^{\Theta}$ for the reaction

$$H - \overset{\overset{H}{|}}{\underset{\underset{Cl}{|}}{C}} - Cl(g) \rightarrow C(g) + 2H(g) + 2Cl(g)$$

[Use table given in Appendix for standard enthalpy of formation]

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46. The enthalpy change (ΔH) for the reaction

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

is -92.38 kJ at 298 K. What is ΔU at 298 K ? $\left(R = 8.314 jK^{-1} mol^{-1}\right)$

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47. A $1.250g$ sample of octane (C_8H_{18}) is burned in excess of oxygen in a bomb calorimeter. The temperature of calorimeter rises from $294.05K$ to $300.78K$. If heat capacity of the calorimeter is $8.93kJK^{-1}$, find the heat transferred to calorimeter.

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48. $20.0g$ of ammonium nitrate (NH_4NO_3) is dissolved In $125g$ of water in a coffee-cup calorimeter, the temperature falls from $296.5K$ to $286.4K$. Find the value of q for the calorimeter. (Hint: heat capacity of water as the heat capacity of the calorimeter and its content)

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49. A chemist while studying the properties of gaseous $C_2Cl_2F_2$, a chlorofluoro carbon refrigerant, cooled a $1.25g$ sample at constant atmospheric pressure of $1.0atm$ from $320K$ to $290K$. During cooling, the sample volume decreased from 274 to $248mL$. Calculate ΔH and ΔU for

the chlorofluoro carbon for this process. For $C_2Cl_2F_2$, $C_P = 80.7 Jmol^{-1}K^{-1}$.

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50. Compounds with carbon-carbon double bond, such as ethylene, C_2H_4, add hydrogen in a reaction called hydrogenation.

$C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$

Calculate enthalpy change for the reaction, using the following combustion data

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(g),$

$\Delta_{comb}H^{\Theta} = -1401 kJmol^{-1}$

$C_2H_6(g) + 7/2O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l), \Delta_{comb}H^{\Theta} = -1550 kJ$

$H_2(g) + 1/2O_2(g) \rightarrow H_2O(l), \Delta_{comb}H^{\Theta} = -286.0 kJmol^{-1}$

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Chemical Equilibrium

1. A liquid is in equilibrium with its vapour in a seated container at a fixed temperature. The volume of the container is suddenly increased.

(a) What is the initial effect of the change on vapour pressure?

(b) How do rates of evaporation and condensation change initially?

(c) What happens when equilibrium is restored finally and what will be the final vapour pressure?

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2. For the reaction, $2SO_{2(g)} + O_{2(g)} \Leftrightarrow 2SO_{3(g)}$ What is K_c when the equilibrium concentration of $[SO_2] = 0.60M, [O_2] = 0.82M$ and $[SO_3] = 1.90M$?

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3. At a certain temperature and total pressures of $10^5 Pa$, iodine vapour contains $40\ \%$ by volume of 1 atoms

$I_2(g) \Leftrightarrow 2I(g)$

Calculate K_p for the equilibrium

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4. Write the expression for the equilibrium constant, K_c for each of the following reaction :

(i) $2NOCl(g) \Leftrightarrow 2NO(g) + Cl_2(g)$

(ii) $2Cu(NO_3)_2(s) \Leftrightarrow 2CuO(s) + 4NO_2(g) + O_2(g)$

(iii) $CH_3COOC_2H_5(aq) + H_2O(l) \Leftrightarrow CH_3COOH(aq) + C_2H_5(aq)$

(iv) $Fe^{3+}(aq) + 3OH^-(aq) \Leftrightarrow Fe(OH)_3(g)$

(v) $I_2(s) + 5F_2 \Leftrightarrow 2IF_5$

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5. Find out of the value of K_c for each of the following equilibrium from the value of K_p:

(i) $2NOCl(g) \Leftrightarrow 2NO(g) + Cl_2(g), K_p = 1.8 \times 10^{-2}$ at $500K$

(ii) $CaCO_3(s) \Leftrightarrow CaO(s) + CO_2(g), K_p = 167$ at $1073K$

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6. For the following equilibrium $K_c = 6.3 \times 10^{14}$ at $1000K$

$NO(g) + O_2(g) \Leftrightarrow NO_2(g) + O_2(g)$

Both the forward the reverse reactions in the equilibrium are elementary bimolecular reactions. What is K_c, for the reverse reaction?

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7. Explain why pure liquids and solids can be ignored while writing the equilibrium constant expression?

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8. Reaction between N_2 and O_2 _ takes place as follows :

$2N_2(g) + O_2(g) \Leftrightarrow 2N_2O(g)$

If a mixture of 0.482 mol N_2 and 0.933 mol of O_2 is placed in a $10L$

reaction vessel and allowed to form N_2O at a temperature for which $K_c = 2.0 \times 10^{-37}$, determine the composition of equilibrium mixutre.

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9. Nitric oxide reacts with Br_2 and gives nitrosul bromide as per reaction given below:

$2NO(g) + Br_2(g) \Leftrightarrow 2NOBr(g)$

When 0.087 mol of NO and 0.0437 mol of Br_2 are mixed in a closed container at constant temperature 0.0518 mol of $NOBr$ is obtained at equilibrium. Calculate equilibrium amount of NO and Br_2.

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10. At $450K$, $K_p = 2.0 \times 10^{10}/\text{bar}$ for the given reaction at equilibrium

$2SO_2(g) + O_2(g) \Leftrightarrow 2SO_2(g)$

What is K_c at this temperature?

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11. A sample of $HI(g)$ is placed in flask at at pressure of 0.2 atm . At equilibrium the partial pressure of $HI(g)$ is 0.04atm what is K_p for the given equilibrium ?

$2HI(g) \Leftrightarrow H_2(g) + I_2(g)$

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12. A mixture of 1.57 mol of N_2, 1.92 mol of H_2 and 8.13 mol of NH_3 is introduced into a $20L$ reaction vessel at $500K$. At this temperature, the equilibrium constant, K_c for the reaction $N_2(g) + 3H_2(g) \Leftrightarrow 2NH_3(g)$ is 1.7×10^2. Is the reaction mixture at equilibrium? If not, what is the direction of the net reaction?

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13. The equilibrium constant expression for a gas reaction is .

$$K_c = \frac{[NH_3]^4[O_2]^5}{[NO]^4[H_2O]^6}$$

Write the balanced chemical equation corresponding to this expression.

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14. One mole of H_2O and one mole of CO are taken in $10L$vessel and heated to $725K$. At equilibrium $40\,\%$ of water (by mass) reacts with CO according to the equation.

$H_2O(g) + CO(g) \Leftrightarrow H_2(g) + CO_2(g)$

Calculate the equilibrium constant for the reaction.

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15. At $700K$, equilibrium constant for the reaction.

$H_2(g) + I_2(g) \Leftrightarrow 2HI(g)$

is 54.8. If $0.5\text{mol}L^{-1}$ of $Hi(g)$ is present at equilibrium at $700K$. What are the concentration of $H_2(g)$ and $I_2(g)$ assuming that we initially started with $HI(g)$ and allowed it to reach equilibrium at $700K$?

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16. What is the equilibirum concentration of each of the substance in the equilibrium when the initial concentration of Icl was $0.78M$?

$2ICl(g) \Leftrightarrow I_2(g) + Cl_2(g), K_c = 0.14$

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17. $K_p = 0.04$ atm at $899K$ for the equilibrium shown below. What is the equilibrium concentration of C_2H_6 when it is placed in a flask at 4.0 atm pressure and allowed to come to equilibrium ?

$C_2H_6(g) \Leftrightarrow C_2H_4(g) + H_2(g)$

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18. Ethyl acetate is formed by the reaction between ethanol and acetic acid and the equilibrium is represented as :

$CH_3COOH(l) + C_2H_5OH(l) \Leftrightarrow CH_3COOC_2H_5(l) + H_2O(l)$

Starting with 0.5 mol of ethanol and 1.0 mol of acetic acid and

maintaining it at 293 K, 0.214 mol of ethyl acetate is found after sometime . Has equilibrium been reached?

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19. A sample of pure PCl_5 was introduced into aln evacuated vessel at 473 K. After equilibrium was attained, concentration of PCl_5 was found to be $0.5 \times 10^{-1} L^{-1}$. If value of K_c is 8.3×10^{-3}. What are the concentration of PCl_3 and Cl_2 at equilibrium ?

$PCl_5(g) \Leftrightarrow PCl_3(g) + Cl_2(g)$

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20. One of the reaction that takes place in producing steel from iron are is the reduction of iron(II) oxide by carbon monoxide to give iron metal and CO_2.

$FeO(s) + CO(g) \Leftrightarrow Fe(s) + CO_2(g)$, $K_p = 0.265$ atm at $1050K$

What are the equilibrium partial pressures of CO and CO_2 and 1050 K if the initial partial pressures are : $p_{CO} = 1.4$ atm and $= 0.80$ atm?

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21. Equilibrium constant, K_c for the reaction

$N_2(g) + 3H_2 \Leftrightarrow 2NH_3(g)$ at $500K$ is 0.061

At a particular time, the analysis shows that composition of the reaction mixture is 3.0 mol $L^{-1}N_2$. $2.0\text{mol}L^{-1}H_2$ and 0.5 mol $L^{-1}NH_3$. Is the reaction at equilibrium?

If not in which direction does the reaction tend to proceed to reach equilibrium?

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22. Bromine monochloride, $BrCl$ decomposition into bromine and chlorine and reaches the equilibrium:

$2BrCl(g) \Leftrightarrow Br_2(g) + Cl_2(g)$

for which $K_c = 32$ at $500K$. If initially pure BrCl is present at a concentration of $3.3 \times 10^{-3}\text{mol}L^{-1}$. What is its molar concentration in the mixture at equilibrium ?

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23. At 1127 K and atm pressure, a gaseous mixture of CO and CO_2 in equilibrium with solid carbon has $90.55\ \%$ CO by mass,

$C_{(s)} + CO_{2(g)} \Leftrightarrow 2CO_{(g)}$

K_c for this reaction at the above temperature is

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24. Calculate a) $\Delta G^{\ominus}$ and b) the equilibrium constant for the formation of NO_2 from NO and NO_2 at $298K$

$NO(g) + \frac{1}{2}O_2 \Leftrightarrow NO_2(g)$

Where

$\Delta_f G^{\ominus}(NO_2) = 52.0kJ/\text{mol}$

$\Delta_f G^{\ominus}(NO) = 87.0kJ/\text{mol}$

$\Delta_f G^{\ominus}(O_2) = 0kJ/\text{mol}$

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25. Does the number of moles of reaction products increase, decrease or remain same when each of the following equilibrium is subjected to a deecrease in pressure by increasing the volume?

(a) $PCl_5(g) \Leftrightarrow PCl_3(g) + Cl_2(g)$

(b) $CaO(s) + CO_2(g) \Leftrightarrow CaCO_3(s)$

(c) $3Fe(s) + 4H_2O(g) \Leftrightarrow Fe_3O_4(s) + 4H_2(g)$

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26. Which the following reaction will get affected by increasing the pressure? Also, mention whether change will cause the reaction to go into forward or backward direction.

(i) $COCl_2(g) \Leftrightarrow CO(g) + Cl_2(g)$

(ii) $CH_4(g) + 2S_2(g) \Leftrightarrow CS_2(g) + 2H_2S(g)$

(iii) $CO_2(g) + C(s) \Leftrightarrow 2CO(g)$

(iv) $2H_2(g) + CO(g) \Leftrightarrow CH_3OH(g)$

(v) $CaCO_3(s) \Leftrightarrow CaO(s) + CO_2(g)$

(vi) $4NH_3(g) + 5O_2(g) \Leftrightarrow 4NO(g) + 6H_2O(g)$

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27. The equilibrium constant for the following reaction is 1.6×10^5 at $1024K$

$H_2(g) + Br_2(g) \Leftrightarrow 2HBr(g)$

Find the equilibrium pressure of all gases if 10.0 bar of HBr is introduced into a sealed container at 1024K.

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28. Dihydrogen gas is obtained from natural gas by partial oxidation with steam as per following endothermic reaction:

$CH_4(g) + H_2O(g) \Leftrightarrow CO(g) + 3H_2(g)$

(a) Write as expression for K_p for the above reaction.

(b) How will the values of K_p and composition of equilibrium mixture be affected by

(i) increasing the pressure

(ii) increasing the temperature

(iii) using a catalyst ?

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29. Describe the effect of :

a) addition of H_2

b) addition of CH_3OH

c) removal of CO

d) removal of CH_3OH

on the equilibrium of the reaction:

$2H_2(g) + CO(g) \Leftrightarrow CH_3OH(dg)$

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30. At $473K$, equilibrium constant K_c for decomposition of phosphorus pentachloride, PCl_5 is 8.3×10^{-3}. If decomposition is depicted as,

$PCl_5(g) \Leftrightarrow Pcl_3(g) + Cl_2, \Delta_r H^{\ominus} = 124.0 kJ \text{mol}^{-1}$

a) write an expression for K_c for the reaction.

b) what is the value of K_c for the reverse reaction at the same temperature ?

c) what would be the effect on K_c if (i) more PCl_5 is added (ii) pressure is increased (iii) the temperature is increased ?

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31. Dihydrogen gas used in Haber's process is produced by reacting methane from natural gas with high temperature steam. The first stage of two stage reaction involves the formation of CO and H_2. In second stage, CO formed in first stage is reacted with more steam in water gas shift reaction,

$$CO(g) + H_2O(g) \Leftrightarrow CO_2(g) + H_2(g)$$

If a reaction vessel at $400^\circ C$ is charged with an equimolar mixture of CO and steam such that $p_{co} = p_{H_2O} = 4.0$ bar, what will be the partial pressure of H_2 at equilibrium? $K_p = 10.1 at 400^\circ C$

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32. Predict which of the following reaction will have appreciable concentration of reactants and products:

a) $Cl_2(g) \Leftrightarrow 2Cl(g) K_c = 5 \times 10^{-39}$

b) $Cl_2(g) + 2NO(g) \Leftrightarrow 2NOCl(g), K_c = 3.7 \times 10^8$

c) $Cl_2(g) + 2NO_2(g) \Leftrightarrow 2NOCl_g, K_c = 1.8$

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33. The value of K_c for the reaction $3O_2(g) \Leftrightarrow 2O_2(g)$ is 2.0×10^{-50} at $25^\circ C$. If the equilibrium concentration of O_2 in air at $25^\circ C$ is 1.6×10^{-2}, what is the concentration of O_3?

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34. The reaction $CO_g + 3H_2(g) \Leftrightarrow CH_4(g) + H_2O(g)$

is at equilibrium at 1300 K in a 1L flask. It also contain 0.30 mol of CO, 0.10 mol of H_2 and 0.02 mol of H_2O and an unknown amount of CH_4 in the flask. Determine the concentration of CH_4 in the mixture. The

equilibrium constant, K_c for the reaction at the given temperature is 3.90.

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35. What is meant by the conjugate acid-base pair? Find the conjugate acid/base for the following species:

$HNO_2, CN^-, HClO_4, F^-, OH^-, CO_{3^{2-}}$ and S^{2-}

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36. Which of the followings are Lewis acids? H_2O, BF_3, H^+ and NH_{4^+}

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37. What will be the conjugate bases for the following Bronsted acids: HF, H_2SO_4 and HCO_3^-?

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38. Write the conjugate acids for the following Brönsted bases: NH_2^-, NH_3 and $HCOO_3^-$.

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39. The species: H_2O, HCO_3^-, HSO_4^- and NH_3 can act both as Brönsted acids and bases. For each case give the corresponding conjugate acid and base.

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40. Classify the following species into Lewis acids and Lewis bases and show how these act as such:

(a) HO^-, (b) F^-, (c) H^+, (d) BCl_3

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41. What will be the pH of a soft drink if hydrogen ion concentration in sample is $3.8 \times 10^{-3} M$?

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42. The pH of a sample of vinegar is 3.76. Calculate the concentration of hydrogen ion in it.

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43. The ionization constant of HF, HCOOH and HCN at 298K are $6.8 \times 10^{-4}, 1.8 \times 10^{-4}$ and 4.8×10^{-9} respectively. Calculate the ionization constants of the corresponding conjugate base.

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44. The ionization constant of phenol is 1.0×10^{-10}. What is the concentration of phenolate ion in 0.05 M solution of phenol? What will

be its degree of ionization if the solution is also $0.01M$ in sodium phenolate?

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45. The first ionization constant of H_2S is 9.1×10^{-8}. Calculate the concentration of HS^- ion in its $0.1M$ solution. How will this concentration be affected if the solution is 0.1M in HCl also ? If the second dissociation constant of H_2S is 1.2×10^{-13}, calculate the concentration of S^{2-} under both conditions.

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46. The ionization constant of acetic acid is 1.74×10^{-5}. Calculate the degree of dissociation of acetic acid in its 0.05 M solution. Calculate the concentration of acetate ion in the solution and its pH.

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47. It has been found that the pH of a 0.01M solution of an organic acid is 4.15. Calculate the concentration of the anion, the ionization constant of the acid and its pK_a.

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48. Assuming complete dissociation, calculate the pH of the following solutions:

(a) 0.003 M HCl , (b) 0.005 M NaOH , (c) 0.002 M HBr , (d) 0.002 M KOH

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49. Calculate the pH of the following solutions :

2 g of TIOH dissolved in water to give 2 litre of solution.

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50. The degree of ionisation of a 0.1 M bromoacetic acid solution is 0.132. Calculate the pH of the solution and the ρK_a bromoacetic acid.

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51. The pH of 0.005 M codeine $(C_{18}H_{21}NO_3)$ solution is 9.95 Calculate its ionisations contant and ρK_b.

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52. What is the pH of $0.001M$ aniline solution? The ionization constant of aniline 4.27×10^{-10}. Calculate the degree of ionization of aniline in the solution. Also calculate the ionization constant of the conjustant acid of aniline.

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53. Calculate the degree of ionisation of 0.05 M acetic acid if its pK_a, value is 4.74. How is the degree of dissociation affected when its solution also contains

(a) 0.01 M

(b) 0.1 M in HCl ?

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54. The ionisation constant of dimethylamine is 5.4×10^{-4} Calculate its degree of ionisation in its 0.02 M solution. What percentage of dimethylamine is ionised if the solution is also 0.1 M in NaOH ?

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55. Calculate the hydrogen ion concentration in the following biological fluids whose pH are given below:

(a) Human muscle-fluid, 6.83 , (b) Human stomach fluid, 1.2

(c) Human blood, 7.38 , (d) Human saliva, 6.4.

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56. The pH of milk, black coffee, tomato juice, lemon juice and egg white are $6.8, 5.0, 4.2, 2.2$ and 7.8 respectively. Calculate corresponding hydrogen ion concentration in each.

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57. If 0.561 g of KOH is dissolved in water to give 200 mL of solution at 298 K. Calculate the concentrations of potassium, hydrogen and hydroxyl ions. What is its pH?

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58. The solubility of $Sr(OH)_2$ at 298 K is 19.23 g/L of solution Calculate the concentration of strontium and hydroxyl ions and the pH of the solutions.

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59. The ionization constant of propanoic acid is 1.32×10^{-5}. Calculate the degree of ionization of the acid in its 0.05M solution and also its pH. What will be its degree of ionization if the solution is 0.01M in HCl also?

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60. The pH of 0.1M solution of cyanic acid (HCNO) is 2.34. Calculate the ionization constant of the acid and its degree of ionization in the solution.

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61. The ionization constant of nitrous acid is 4.5×10^{-4}. Calculate the pH of 0.04 M sodium nitrite solution and also its degree of hydrolysis.

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62. A 0.02M solution of pyridinium hydrochloride has pH = 3.44. Calculate the ionization constant of pyridine.

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63. Predict if the solutions of the following salts are neutral, acidic or basic: $NaCl$, KBr, $NaCN$, NH_4NO_3, $NaNO_2$ and KF

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64. The ionization constant of chloroacetic acid is 1.35×10^{-3}. What will be the pH of 0.1M acid and its 0.1M sodium salt solution?

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65. Ionic product of water at 310 K is 2.7×10^{-14}. What is the pH of neutral water at this temperature?

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66. Calculate the PH of the resultant mixture :

10 mL of 0.2 M $Ca(OH)_2$ + 25 mL of 0.1 M HCl

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67. Determine the solubilities of silver chromate, barium chromate, ferric hydroxide, lead chloride and mercurous iodide at $298K$ from theor solubility product constants given in Table 7.9. Determine also the molarities of individual ions.

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68. The solubility product constant of Ag_2CrO_4 and $AgBr$ are 1.1×10^{-12} and 5.0×10^{-13} respectively. Calculate the ratio of the molarities of their saturated solutions.

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69. Equal volumes of 0.002 M solutions of sodium iodate and cupric chlorate are mixed together. Will it lead to precipitation of copper iodate? (For cupric iodate $Ksp = 7.4 \times 10^{-8}$).

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70. The ionization contant of benzoic acid is 6.46×10^{-5} and K_{sp} for silver benzoate is 2.5×10^{-13}. How many times is silver benzoate more soluble in abuffer of pH=3.19 compared to its solubility in pure water ?

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71. What is the maximum concentration of equimolar solutions of ferrous sulphate and sodium sulphide so that when mixed in equal volumes, there is no precipitation of iron sulphide? (For iron sulphide, $K_{sp} = 6.3 \times 10^{-18}$).

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72. What is the minimum volume of water required to dissolve 1g of calcium sulphate at 298 K? (For calcium sulphate, K_{sp} is 9.1×10^{-6}).

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73. The concentration of sulphide ion in 0.1M HCl solution saturated with hydrogen sulphide is 1.0×10^{-19} M. If $10mL$ of this is added to $5mL$ of $0.04M$ solution of the following: $FeSO_4$, $MnCl_2$, $ZnCl_2$ and $CdCl_2$. in which of these solutions precipitation will take place?

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