CHEMISTRY

BOOKS - CENGAGE CHEMISTRY (HINGLISH)

NCERT BASED EXERCISE

Some Basic Concepts And Mole Concept

1. Calculate the molecular mass of the following:

a. H_2O

b. CO_2

c. CH_4

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

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3. Detennine 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

a. 1 mol of carbon is burnt in air

b. 1 moles of carbon is brunt in $16g$ of dioxygen.

2 moles of carbon are burnt in $16g$ of dioxygen.

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5. Calculate the mass of sodium acetate (CH_3COONa) required to make $500mL$ of 0.375 molar qqueous solution. Molar mass of sodium of acetate is $82.0245gmol^{-1}$.

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6. Calculate the concentration of nitric acid in moles per litre in a sample which has a density $1.41g/mL$ and the mass percent of nitric acid in it being 69%.

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

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8. Determine the molecular formula of an oxide of iron in which the mass percent 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 the moles of ethane (C_2H_6), calculate the following:

a. Number of moles of carbon atoms

b. Number of moles of hydrogen stoms

c. 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 $20g$ are dissolved in enough water to make a final volume up to $2L$?

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

$1Pa = Nm^{-2}$

If the mass of air at sea level is $1034gcm^{-2}$, 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 be severely contaminated with chloroform, $CHCl_3$, which is supposed to be carcinogenic in nature. The level of contamination was $15 ppm$ (by mass).

a. Express this is precent by mass.

b. determine the molarity of chloroform in the water sample.

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17. Express the following in the scientific notation:

a. 0.0048

b. 234000

c. 8008

d. 500.0

e. 6.0012

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

a. 0.0025

b. 208

c. 5005

d. 126000

e. 500.0

f. 2.0034

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19. Round up the following upto three significant figures:

a. 34.216

b. 10.4107

c. 0.04597

d. 2808

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20. The following data are obtained when dinitrogen and dioxygen react to gether 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. $1km =$ ..... $mm =$ .....pm

II. $1mg =$ ..... $kg =$ ..... ng

III. $1mL =$ .....$L =$ ..... dm^3

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21. If the speed of light is $3.0 \times 10^8 ms^{-1}$, calculate the distance covered by light in $2.00ns$.

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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 chemical equation:

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

a. Calculate the mass of ammonia produced if $2.00 \times 10^3 g$ dinitrogen reacts with $1.00 \times 10^3 g$ of dihydrogen.

b. Will any of the two reactants remain unreacted?

c. 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 reats 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:

a. $28.7pm$

b. $15.15pm$

c. $25365mg$

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

a. $1gAu(s)$

b. $1gNa_4(s)$

c. $1gLi(s)$

d. $1gCl_2(g)$

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28. Calculate the molarity of a solution of ethnol in water in which the mole fraction of ethanol is 0.040.

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29. What will be the mass of one $.^{12}C$ atom in g?

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

a. $\frac{0.02856 \times 298.15 \times 0.112}{0.5785}$

b. 5×5.364

c. $0.0125 + 0.7864 + 0.0215$

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31. Use data given in the following table to calculate the molar mass of naturaly occuring argo 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

a. $52mol$ of He

b. $52u$ of He

c. $52g$ 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 litre (Measured at STP) of this welding gas is found weigh $11.6g$. 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:

$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

What mass of $CaCO_3$ is required to react completely with $25mL$ of $0.75MHCl$?

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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 gram of HCl react with $5.0g$ of manganese water to make $250.0mL$ solution.

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Redox Reaction

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

a. NaH_2PO_4

b. $NaH\underline{S}O_4$

c. $H_4\underline{P_2}O_7$

d. $K_2\underline{Mn}O_4$

e. $\underline{Ca}O_2$

f. $Na\underline{B}H_4$

g. $H_2\underline{S_2}O_7$

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. $K\underline{I}_3$ b. $H_2\underline{S}_4O_6$ c. $\underline{Fe}_3O_4$

d. $\underline{C}H_3\underline{C}H_2OH$

e. $\underline{C}H_3\underline{C}OOH$

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3. Justify that the following reaction 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. $2K(s) + F_2(g) \rightarrow 2K^{\oplus}F^{\Theta}(s)$

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^{Θ}. Suggest the structure of these compounds.

Count for the fallacy.

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6. Write formulas for the following compounds:

a. Mercury (II) chloride b. Nickel (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 $+4$ amd nitrogen from -3 to $+5$.

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8. While sulphate dioxide and hydrogen perxide 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) $6CO_2(g) + 6H_2O(I) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

b) $O_3(g) + H_2O_2(I) \rightarrow H_2O(I) + 2O_2(g)$

Why it is more appropriate to write these reaction as

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

b) $O_3(g) + H_2O_2(I) \rightarrow H_2O(I) + O_2(g) + O_2(g)$

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 an unstable compound. However, if formed, the compound acts as a 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 count for the following observations?

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

b. When concentrated sulphuric acid added to an inorganic mixture containing chloride, we get colourless pungent smelling gas HCl, but if the mixture contains bromide then we get red vapour og bromine. why?

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

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

b.

$HCHO(l) + 2\left[Ag(NH_3)_3\right]^{\oplus} + 3\overset{\Theta}{O}H(aq) \rightarrow 2Ag(s) + HCOO^{\Theta}(aq) + 4N$

c.

$HCHO(l) + 2Cu^{2+}(aq) + 5\overset{\Theta}{O}H(aq) \rightarrow Cu_2O(s) + HCOO^{\Theta}(aq) + 3H_2O$

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

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

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14. Consider the reaction:

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

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

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

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15. Justify giving reaction 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?

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

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.

$H_3PO_2(aq) + 4AgNO_3(aq) + 2H_2O(l) \rightarrow H_3PO_4(aq) + 4Ag(s) + 4HNO$

b.

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

c.

$C_6H_5CHO(l) + 2\left[Ag(NH_3)_2\right]^{\oplus}(aq) + 3\overset{\Theta}{O}H(aq) \rightarrow C_6H_5COO^{\Theta}(aq) + 2$

d. $C_6H_5CHO(l) + 2Cu^{2+}(aq) + 5\overset{\Theta}{O}H(aq) \rightarrow$ No change observed

Wahat inference do you draw about the behaviour of $Ag^{\oplus}$ and Cu^{2+} from these reaction?

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18. Balance the following rebox reactions by ion electron method:

a. $MnO_4^{\Theta}(aq) + I^{\Theta}(aq) \rightarrow MnO_2(s) + I_2(s)$ (in basic medium)

b. $MnO_4^{\Theta}(aq) + SO_2(g) \rightarrow Mn^{2+}(aq) + HSO_4^{\Theta}(aq)$ (in acidic solution)

c. $H_2O_2(aq) + Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + H_2O(l)$ (in acidic solution)

d. $Cr_2O_7^{2-} + SO_2(g) \rightarrow Cr^{3+}(aq) + SO_4^{2-}(aq)$ (in acidic solution)

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

(a) $P_4(s) + \overset{\Theta}{O}H(aq) \rightarrow PH_3(g) + H_2PO_2^{\Theta}$

(b) $N_2H_4(l) + ClO_3^{\Theta}(aq) \rightarrow NO(g) + Cl^{\Theta}(g)$

(c) $Cl_2O_7(g) + H_2O_2(aq) \rightarrow ClO_2^{\Theta}(aq) + O_2(g) + H^{\oplus}$

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

$(CN)_2(g) + 2\overset{\Theta}{O}H(aq) \rightarrow CN^{\Theta}(aq) + CNO^{\Theta}(aq) + H_2O(l)$

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21. The Mn^{3+} ion is unstable in solution and undergoes desproportionation reaction to give Mn^{+2}, MnO_2, and $H^{\oplus}$ ion. Write a balanced ionic 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 positive 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 talking 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 amonia gas by oxygen gas to give nitric oxide gas and steam. What is the maximum weight of nitric oxide that can obtained starting only with $10.00g$ of ammonia and $20.00g$ of oxygen?

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Atomic Structure

1. (i) Calculate the number of electrons which will together with one gram

.

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

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2. (i) Calculate the total number of electrons present in 1 mole of methane .

(ii) Find (a) the total number and (b) the total mass of neutrons in 7 mg of $.^{14}C$. (Assume that mass of a neutron $= 1.675 \times 10^{-27} g$)

(iii) Find (a) the total mnumber of protons and (b) the total mass fo protons in $32mg$ of NH_3 at STP. (mass of proton $= 1.672 \times 10^{-27} g$)

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

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

$._6 C^{12}, ._8 O^{17}, ._{12} Mg^{25}, ._{26} Fe^{56}, ._{38} Sr^{88}$

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

a. $Z = 17, A = 35,$

b. $Z = 92, A = 233,$

c. $Z = 4, A = 9$

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5. Yellow light emitted from a sodium lamp has a wavelength (λ) of $580nm$. Calculate the frequency (v). Wave number and energy of yellow light photon .

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6. Find energy of each of the photons which

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

b. have wavelength of 0.50Å.

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7. Calculate the wavelength, frequency, and wave number 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 wavelngth of $400pm$ that provide $1J$ of energy ?

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9. A photon of wavelength $4 \times 10^{-7} m$ strikes on metal surface , the work function fo the metal being $2.13eV$ Calculate :

(i) the energy of the photon (ev)

(ii) the kinetic energy fo the emission and

the velocity fo 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 a sodium atom. Calculate the energy corresponding to this wavelength and the ionisation potential of Na.

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11. A 25 watt bulb emits monochromatic yellow light of wavelength of 0.57μ m. Calculate the rate of emission of 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 Å . Calculate threshold

frequency (v_0) and work function (W_0) of the metal.

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13. What is the wavelength of light emitted when the electron of a hydrogen atom undergoes a transition from an energy level with $n = 4$ to an energy level with $n = 2$? What is the colour corresponding to this wavelength?

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14. How much energy is required to ionise an H atom if the electron occupies $n = 5$ orbit? Compare your answer with the ionisation enthaply of H atom (anargy required to remove the electronic from $n = 1$ orbit).

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

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16. a. 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?

b. Calculate the radius of Bohr's fifth orbit for hydrogen atom.

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17. Calculate the wave number for the shortest wavelength transition in the Balmer series of atomic hydrogen.

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18. What is the energy in joules required to shift the elertcon 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 -218×10^{-11} erg.

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19. The electron energy in hydrogen atom is given by $E_n = \left(-2.18 \times 10^{-8}\right)/n^2 J$. 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 velocity fo $2.05 \times 10^7 ms^{-1}$.

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21. The mass of an electron is $9.1 \times 10^{-31} kg$. 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:

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

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23. i. Write the electronic conifigurations of the following ions:

a. H^{Θ}, b. $Na^{\oplus}$, c. O^{2-}, d. F^{Θ}

ii. What are the atomic numbers of elements whose outermost electrons are represented by

a. $3s^1$, b. $2p^3$, c. $3p^5$?

iii. Which atoms are indicated by the following configurations?

a. $[He]2s^1$, 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 orbitals to exist?

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25. An eletron is in one of the $3d$ orbitals. Give the possible values of n, l, and m_1 for this electron.

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26. An atom of an element contains 29 electrons and 35 netrons. Deduce

a. The number of protons and

b. The elctonic configuration of the element.

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27. Give the number of electrons in the species H_2^+, H_2 and $O_2^{\oplus}$

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28. a. An atomic orbital has $n = 3$. What are the possible values of l and m?

b. List the quantum numbers $(m_1 \text{ and } l)$ of electons for $3d$ orbital.

c. Which of the following orbitals are possible" lp, $2s$, $2p$, and $3f$?

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29. Using s, p, d notations, descibe the orbital with the following quantum numbers.

a. $n = 1, l = 0$, b. $n = 3, l = 1$

c. $n = 4, l = 2$, d. $n = 4, l = 3$

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30. Explain , giving reason , which of the following sets of quantum number are not possible

a	$n=0$	$l=0$	$m_1=0$	$m_s=+1/2$
b	$n=1$	$l=0$	$m_1=0$	$m_s=-1/2$
c	$n=1$	$l=1$	$m_1=0$	$m_s=+1/2$
d	$n=2$	$l=1$	$m_1=0$	$m_s=-1/2$
e	$n=3$	$l=3$	$m_1=-3$	$m_s=+1/2$
f	$n=3$	$l=1$	$m_1=0$	$m_s=+1/2$

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31. How many electron in an atom may have the following quantum number ?

a. $n=4, m_s=-\frac{1}{2}$

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 $n = 4$ to $n = 2$ of $He^{\oplus}$ spectrum?

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34. Calcultte the enrgy required for the process ,

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

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

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35. If the diameter of a carbon atom is $0.15nm$, calculate the number of carbon atom which can be placed side by side in a straight line length of scale of length $20cm$ 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 $2.4cm$.

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37. The diameyer of zinc atom is $2.6A$. Calculate (a) radius of zinc atom in pm and (b) number of atoms present in a length of $1.6cm$ 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 electrons 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, such as gold, platinum, etc. have been used to be bombarded by the α-particles. If the thin foil of light atoms such as aluminium atc. Is used, what difference would be observed form 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 off negative charge. If the ion contains 11.1% more neutrons than 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 then 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 ragio

d. Consmic rays from outer space and

e. X-rays

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46. Nitrogen laser produces a radiation at a wavelength of $33.71nm$. 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 $616nm$, calculate

a. The frequency of emission,

b. The distance travelled by this radiation in $30s$

c. The energy of quantum and

d. The number of quanta present if it produces $2J$ 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 $600nm$, calculate the number of photons received by the detector.

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49. Lifetimes of the molecules in the ecited 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 is 2.5×10^{15}, calculate the energy of the source.

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50. The longest wavelength doublet absorption is observed at 589 and $589.6nm$. Caiculate the frequency of each transition and energy differebce between two excited states.

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51. The work function for caesium atom is $1.9eV$. Calculate (a) the threshold wavelength and (b) the threshold frequency of the radiation. If the caesium element is irradiated with a wavelength $500nm$, 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 wavelengths. 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 photonelectric effect exeriment can be stopped by applying the voltage of $0.35V$ when the radiation $256.7nm$ is used. Calculate the work function for silver metal.

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54. If the photon of the wavelength $150pm$ 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 transitions 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 1285 nm. 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 $1.3225nm$ ends at $211.6pm$. 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 magnefied images of biological molecules and other type of material. If the velocity of the electron in this microcope 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 $800pm$, calculate the characteristic velocity associted with the neutran.

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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 velocity associated with a proton moving in a potential difference of $1000V$ is $4.37 \times 10^5 ms^{-1}$. If the hockey ball of mass $0.1kg$ 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 $\pm 0.002nm$. 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 number of electrons are given below: Arrange them in order of increasing energies

a. $n = 4, l = 2, m_l = -2, m_s = -\frac{1}{2}$

b. $n = 3, l = 2, m_l = 1, m_s = +\frac{1}{2}$

c. $n = 4, l = 1, m_l = 0, m_s = +\frac{1}{2}$

d. $n = 3, l = 2, m_l = -2, m_s = -\frac{1}{2}$

e. $n = 3, l = 1, m = -1, m_s = +\frac{1}{2}$

f. $n = 4, l = 1, m_l = +1, m_s = +\frac{1}{2}$

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63. The bromine atom possesses $3s$ electrons. It contains six electrons in $2p$ orbitals, six electrons in $3p$ orbitals and five electrons in $4p$ orbitals. Which of these electrons experience the lower effective nuclear charge?

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64. Among the following pairs of orbital which orbital will experience the larger effective nuclear charge?

a. $2s$ and $3s$, b. $4d$ and $4f$, c. $3d$ 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, $e.\ Kr$

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67. a. How many sub-shell are associated with $n = 4$?

b. How many electron will be present in the sub-shell having m_s value of $-1/2$ for $n = 4$?

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68. What will be the minimum pressure required to compress $500 dm^3$ of air at 1bar 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 1.2 bar pressure and $35^{\circ}C$. 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 the density of gas is proportional to gas pressure p.

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71. At $0^{\circ}C$ the density of a gaseous oxide at 2 bar is same as that of nitrogen at 5 bar What is the molecular mass of the oxide ? .

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72. Pressure of $1g$ of an ideal gas A at $27^\circ C$ is found to be 2 bar when $2g$ of another ideal gas B is introduced in the same flask at same temperature the pressure becomes 3 bar. Find a relationship thieir molecular masses .

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

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74. What will be the pressure exerted by a mixture of $3.2g$ of methane and $4.4g$ of carbon dixide contained in a $9dm^3$ flask at $27^\circ C$? .

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75. What will be the pressure of the gas mixture when $0.5L$ of H_2 at 0.8 bar $2.0L$ of oxygen 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 $5.46/dm^3$ at $27^\circ C$ at 2 bar pressure What will be its density at STP ? .

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77. $34.05mL$ of phosphorus vapours weighs $0.0625g$ at $546^\circ C$ and 0.1 bar pressure. What is the molar mass of phossphorus ?

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78. A student forgot to add the reaction mixture to the round bottomed open flask at $27^\circ C$ and put it on the flame After a lapse of time he

realized his mistake 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.

Strategy : List the variables with the proper units. Then solve the ideal gas equation for T by substituting the values.

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80. Calculate the total number of electrons presents in $1.4 g$ of nitrogen gas.

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

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82. Calculate the total pressure in a mixture og $8g$ of oxygen and $4g$ hydrogen confined in a vessel of $1dm^3$ at $27^\circ C$. $\left(R = 0.083 \text{bar} dm^3 K^{-1} mol^{-1}\right)$

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83. Pay load is defined as the difference between the mass of displaced air and the mass of the ballon 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 $R = 0.083$ nar $dm^{-3}K^{-1}mo1^{-1}$) .

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84. Calculate the volume occupied by $8.8g$ of CO_2 at $31.3^\circ C$ and 1 bar pressure. $\left(R = 0.083 \text{bar} LK^{-1}mol^{-1}\right)$

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

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86. A mixture of hydrogen and oxygen at 1 bar pressure contains 20% of hydrogen by weight. Calculate the partial pressure of hydrogen.

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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. The critical temperatures of carbon dioxide and methane are $31.1^{\circ}C$ and $-81.9^{\circ}C$, respectively. Which of them 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. Through the two ends of a glass tube of length $200cm$ hydrogen chloride gas and ammonia are allowed to enter At what distance

ammonium chloride will first appear ? .

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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 ethnalpies of all element in their states are:

A. Unity

B. Zero

C. < 0

D. Different for each element

Answer: b

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4. ΔU^{Θ} of combustion of methane is $-XkJmol^{-1}$. The value of ΔH^{Θ} 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 $298K$ are, $-890.3kJmol^{-1} - 393.5kJmol^{-1}$, and $-285.8kJmol^{-1}$

respectively. Enthapy 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, $701J$ of heat is obsorbed by a system and $394J$ 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 $298K$. Calculate enthalpy change for the reaction at $298K$.

$$NH_2CN(g) + \frac{3}{2}O_2(g) \rightarrow N_2(g) + CO_2(g) + H_2O(l)$$

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

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10. The enthalpy change on freezing of 1 mol of water at $5^\circ C$ to ice at $-5^\circ C$ is:

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

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

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

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11. Enthalpy of combustion of carbon to CO_2 is $-393.5kJmol^{-1}$. Calculate the heat released upon formation of $35.2g$ of CO_2 from carbon and dioxygen gas.

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12. Find the value of $\Delta_f H^\circ$ for the reaction

$N_2O_4(g) + 3CO(g) \rightarrow N_2O(g) + 3CO_2(g)$

Standard enthalpies of formation of $CO(g), CO_2(g), N_2O(g)$, and $N_2O_4(g)$ are $-110, -393, 81$, and $9.7 kJ mol^{-1}$, respectively.

Strategy : The standard enthalpy change of a reaction is equal to the sum of the standard molar enthalpie of formation of the products each multiplied by its stiochiometric coefficient in the balanced equation, minus the corresponding sum of the standard molar enthalpies of formation of the reactants

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13. Given

$N_2(g) + 3H_2(g) = 2NH_3(g), \Delta H^\circ = -22 kcal$. The standard enthapy of formation of NH_3 gas is

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

$CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l), \ldots(i), \Delta_r H_1^{\Theta} = -726kJm$

$C(g) + O_2(g) \rightarrow CO_2(g), \ldots(ii), \Delta_c H_2^{\Theta} = -393kJmol^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \ldots(iii), \Delta_f H_3^{\Theta} = -286kJmol^{-1}$

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15. Calculate the enthalpy change for the process

$CCl_4(g) \rightarrow C(g) + 4Cl(g)$

and calculate bond enthalpy of $C - Cl$ in $CCl_4(g)$.

$\Delta_{vap}H^{\Theta}(CCl_4) = 30.5kJmol^{-1}$

$\Delta_f H^{\Theta}(CCl_4) = -135.5kJmol^{-1}$

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

$\Delta_a H^{\Theta}(Cl_2) = 242kJmol^{-1}$

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16. For an isolated system, $\Delta U = 0$. What will be the value of ΔS?

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17. For the reaction at $298K$

$2A + B \rightarrow C$

$\Delta H = 400kJmol^{-1}$ and $\Delta S = 0.2kJK^{-1}mol^{-1}$

At what temperature will the reaction becomes spontaneous considering

ΔH and ΔS to be contant over the temperature range.

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18. For the reaction

$2Cl(g) \rightarrow Cl_2(g)$, what are the signs of ΔH and ΔS?

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19. For the reaction,

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

$\Delta U^{\Theta} = -10.5kJ$ and $\Delta S^{\Theta} = -44.1JK^{-1}$

Calculate ΔG^{Θ} 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}? $R = 8.314JK^{-1}mol^{-1}, T = 300K.$

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21. Comment on the thermodynamic stability of $NO(g)$, given

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

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

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22. Calculate the entropy change in surroundings when 1.00 mol of $H_2O(l)$ is formed under standard conditions, $\Delta_r H^{\Theta} = -286 kJ mol^{-1}$.

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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 exotermic 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 $368kJmol^{-1}$, 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 enthalpu? Explain both the trms 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 rae 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. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

b. $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$

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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.

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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 $Delat_rH^{\ominus}$ for the reaction

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

[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 $-92.38kJ$ at $298K$. What is ΔU at $298K$?

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47. A 1.250 g sample of octane (C_8H_{18}) is burned in excess of oxygen in a bomb calorimeter. The temperatre of the calorimeter rises from 294.05 K to 300.78K. If heat capacity of the calorimeter is 8.93kJ/K, find the heat

transferred to the calorimeter. Also calculate the enthalpy combustion of the sample of octane.

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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 $C_2Cl_2F_2$, $C_P = 80.7Jmol^{-1}K^{-1}$.

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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

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

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

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

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

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Chemical Equilibrium

1. A liquid is in equilibrium with its vapour in a sealed 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. What is K_c for the following equilibrium concentration of each substance is:

$[SO_2] = 0.60M$, $[O_2] = 0.82M$ and $[SO_3] = 1.90M$?

$2SO_2(g) + O_2(g) \Leftrightarrow 2SO_3(g)$

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3. At a certain temperature and a total pressure of $10^5 Pa$, iodine vapour contains $40\ \%$ by volume of $I\text{atoms}$, Calculate K_p for the equilibrium.

$I_{2(g)} \Leftrightarrow 2I_{(g)}$

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

a. $2NOCl(g) \Leftrightarrow 2NO(g) + Cl_2(g)$

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

c. $CH_3COOC_2H_5(aq) + H_2O(1) \Leftrightarrow CH_3COOH(aq) + C_2H_5OH(aq)$

d. $Fe^{3+}(aq) + 3OH^{\Theta}(aq) \Leftrightarrow Fe(OH)_3(s)$

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

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

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

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

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

$NO(g) + O_3(g) \Leftrightarrow NO_2(g) + O_2(g)$

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

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7. Concentration of pure solid and liquid is not included in the expression of equilibrium constant because

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8. Reaction between nitrogen and oxygen takes place as following:

$2N_{2(g)} + O_2 \Leftrightarrow 2N_2O_{(g)}$

If a mixture of $0.482 \text{mole} N_2$ and 0.933mole of O_2 is placed in a reaction vessel of volume $10 litre$ and allowed to form N_2O at a temperature for which $K_c = 2.0 \times 10^{-37} litremol^{-1}$. Determine the composition of equilibrium mixture.

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9. Nitric oxide reacts with bromine and gives nitrosyl-bromide as per reaction given below:

$2NO_{(g)} + Br_{2(g)} \Leftrightarrow 2NOBr_{(g)}$.

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

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

$2SO_2(g) + O_2(g) \Leftrightarrow 2SO_3(g)$

What is K_c at this temperature?

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11. A sample of $HI(g)$ is placed in flask at a pressure of $0.2atm$. 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 $1.57mol$ of N_2, $1.92mol$ of H_2 and $8.13mol$ 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 balance chemical chemical equation corresponding to this expression.

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14. One mole of H_2O and one mole of CO are taken in a $10litre$ vessel and heated to $725K$. At equilibrium, $40percent$ of water (by mass) reacts with carbon monoxide 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 $0.5mollitre^{-1}$ of $HI_{(g)}$ is present at equilibrium at $700K$, what are the concentrations 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 equilibrium concentration of each of the substance in the euilibrium 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. $K_p = 0.04atm$ at $899K$ for the equilibrium shown below. What is the equilibrium concentration of C_2H_6 when it is placed in a flask at $4.0atm$ pressure and allowed to come to equilibrium?

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

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18. The ester, ethyl acetate is formed by the reaction between ethanol and acetic acid and equilibrium is represented as:

$CH_3COOH_{(l)} + C_2H_5OH_{(l)} \Leftrightarrow CH_3COOC_2H_{5_{(aq)}} + H_2O_{(l)}$

(a) Write the concentration ratio (reaction quotient), Q_e, for this reaction. Note that water is not in excess and is not a solvent in this reaction.

(b) At $293K$, if one starts with 1.00mole of acetic acid and 0.180 of ethanol, there is 0.171mole of ehtyl acetate in the final equilibrium mixture. Calculate the equilibrium constant.

(c) Starting with 0.500mole of ethanol and 1.000mole of acetic acid and maintaining it at $293K$, 0.214mole of ethyl acetate is found after some time. Has equilibrium been reached?

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

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20. One of the reaction that takes plece in producing steel from iron ore 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 pressure of CO and CO_2 at $1050K$ if the partical pressure are: $p_{CO} = 1.4atm$ and $p_{CO_2} = 0.80atm$?

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21. Equilibrium constant, K_c for the reaction,

$N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)}$,

at $500K$ is $0.061 litre^2 \text{mole}^{-2}$. At a particular time, the analysis shows that composition of the reaction mixture is $3.00 mollitre^{-1} N_2$, $2.00 mollitre^{-1} H_2$, and $0.500 mollitre^{-1} NH_3$. 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, $(BrCl)$ decomposes 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 $3.30 \times 10^{-3} mollitre^{-1}$, what is its molar concentration in the mixture at equilibrium?

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23. At $1127K$ and $1atm$ pressure, a gaseous mixture of CO and CO_2 in equilibrium with solid carbon has $90.55\ \%\ CO$ by mass:

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

Calculate K_c for the reaction at the above temperature.

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24. Calculate $(a)\Delta G^{\Theta}$ and (b) the equilibrium constant for the formation of NO_2 from NO and O_2 at 298 K

$NO(g) + 1/2O_2(g) \Leftrightarrow NO_2(g)$ where

$\Delta_f G^{\Theta}(NO_2) = 52.0kJ/mol, \Delta_f G^{\Theta}(NO) = 87.0kJ/mol, \Delta_f G^{\Theta}(O_2) =$

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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 decrease 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 of the following reactions will get affected by increasing the pressure? Also, mention whether change will cause the reaction the reaction to go into forward of backward direction.

a. $COCl_2(g) \Leftrightarrow CO(g) + Cl_2(g)$

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

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

d. $2H_2(g) + CO(g) \Leftrightarrow CH_3OH(g)$

e. $CaCO_3(s) \Leftrightarrow CaO(s) + CO_2(g)$

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

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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 obtaines 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 an expression for K_(p) for the above reaction.

b. How will the value 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. Decribe 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:

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

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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,

$PCl_5(g) \Leftrightarrow PCl_3(g) + Cl_2(g) \Delta_r H^{\Theta} = 124.0 kJ mol^{-1}$

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 the two 2 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 reactions will have appreciable concentration of rectants 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. $Cl_2(g) + 2NO_2(g) \Leftrightarrow 2NO_2Cl(g)$, $K_c = 1.8$

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33. The value of K_c for the reaction $3O_2(g) \Leftrightarrow 2O_3(g)$ is 2.0×10^{-50} at $25^\circ C$. If the equilibrium aoncentration 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 $1300K$ in a $1L$ flask. It also contains $0.30mol$ of CO, $0.10mol$ 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 us 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:

$HNO_2, CN^{\Theta}, HClO_4, F^{\Theta}, \overset{\Theta}{O}H, CO_3^{2-}$, and S^{2-}

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36. Which of the followings are Lewis acids: H_2O, BF_3, $H^{\oplus}$ and NH_4?

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37. Write the conjugate bases for the following Brddotonsted acids

(a) HF (b) H_2SO_4 (c) HCO_3^{Θ}

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38. Wirte the conjugate acids for the following Brdddotosted bases:

a. $\overset{\Theta}{N}H_2$ b. NH_3 c. $HCOO^{\Theta}$

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39. The species: $H_2O, HCO_3^{\Theta}, HSO_4^{\Theta}$ and NH_3 can act both as Bronsted 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 Lewis acid / base:

a. $\overset{\Theta}{O}H$, b. F^{Θ}, c. $H^{\oplus}$, d. BCl_3

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

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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 6.8×10^{-4}, 1.8×10^{-4} and 4.8×10^{-9} respectively. Calculate the

ionization constant 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 $0.05M$ 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^{Θ} 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 if 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 1.74×10^{-5}. Calculate the degree of dissociation of acetic acid in its $0.05M$ 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 orginic 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. $0.003MHCl$, b. $0.005MNaOH$,

c. $0.002MHBr$, d. $0.002MKOH$

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49. Calculate the pH of the following solutions:

a. $2g$ of $TlOH$ dissolved in water to give 2 litre of solution.

b. $0.3g$ of $Ca(OH)_2$ dissolved in water to give $500mL$ of solution.

c. $0.3g$ of $NaOH$ dissolved in water to give $200mL$ of solution.

d. $1mL$ of $13.6MHCl$ is duluted with water to give 1 litre of solution.

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50. The degree of ionisation of a $0.1M$ bromoacetic acid solution is 0.13. Calculate the pH of the solution and the pK_a of bromoacetic acid.

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51. The pH of $0.005M$ codine $(C_{18}H_{21}NO_3)$ solution is 9.95. Calculate its ionisation constant and pK_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 $0.05M$ acetic acid if its pK_a value is 4.74. How is the degree of dissociation affected when its solution also contains

a. $0.01M$, b. $0.1M$ in HCl?

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54. The ionisation constant os dimethylamine is 5.4×10^{-4}. Calculate its degree of ionization in its $0.02M$ solution. What percentage of dimethylamine is ionized if the solution is also $0.1M$ 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 $0.561g$ of (KOH) is dissolved in water to give. $200mL$ of solution at $298K$. Calculate the concentration of potassium, hydrogen and hydroxyl

ions. What is its pH?

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58. The solubility of $Sr(OH)_2$ at $298K$ is $19.23gL^{-1}$ of solution. Calculate the concentrations cf strontium and hydroxyl ions and the pH of the solution.

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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 $0.01M$ on 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 its degree of ionisation in the solution.

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

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

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63. Predict if the solution of the following salts are netural, 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 $310K$ is 2.7×10^{-14}. What is the pH of netural water at this temperature?

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66. Calculate the pH of the resultant mixture:

a. $10mL$ of $0.2MCa(OH)_2 + 25mL$ of $0.1MHCl$

b. $10mL$ of $0.01MH_2SO_4 + 10mL$ of $0.01MCa(OH)_2$.

c. $10mL$ of $0.1MH_2SO_4 + 10mL$ of $0.1MKOH$.

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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 solution of sodium iodate and cupric chlorate are mixed togather. Will it lead to precipitation of copper iodate?

$\left(\text{for cupric iodate} K = 7.4 \times 10^{-8}\right)$.

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70. 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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71. What is the minimum volume of water required to dissolve $1.0g$ of calcium sulphate at $298K$?

(For calcim sulphae , $K_{sp} is 9.1 \times 10^{-6}$).

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

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