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S6 CHEMISTRY

Exam 10

PAPER 1

DURATION: 2 HOUR 45 MINUTES

For Marking guide contact and consultations: Dr. Bbosa Science 0776 802709,

Instructions

- This paper consists of two sections A and B
- Section A is compulsory
- Attempt only six questions in section B
- Answers must be written in the spaces provided only.

For Examiner's Use Only																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

SECTION A

Answer all questions from this section

1. Oxygen diffused through a porous partition in 1.87 minutes. Under similar conditions the same volume of an alkene T diffused in 2.15 minutes

   (a) Determine the formula of T (2 ½ marks)

$$\frac{rate\ oxygen}{rate\ T} = \sqrt{\frac{RFM\ of\ T}{RFM\ of\ oxygen}}$$

$$\frac{\frac{V}{1.87}}{\frac{V}{2.15}} = \sqrt{\frac{RFM\ of\ T}{32}}$$

RFM of T = 42

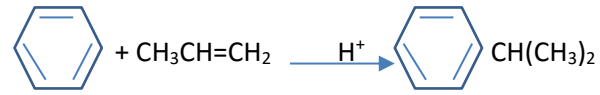
$(C_nH_{2n})x = 42$

x =3

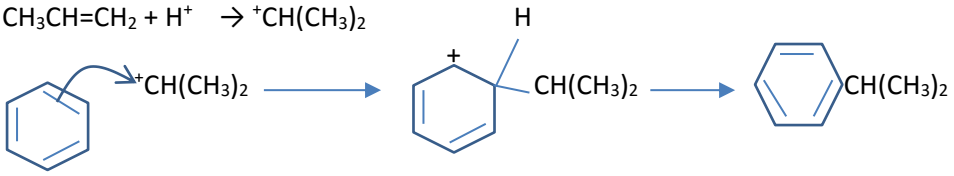
Molecular formula of alkene = C_3H_6 or $CH_3CH{=}CH_2$

   (b) Write equation and outline the mechanism for the reaction between T and benzene.

   Indicate the condition (s) for the reaction (3marks)



$CH_3CH{=}CH_2 + H^+ \rightarrow {}^+CH(CH_3)_2$



2. (a) define the term heat of reaction (1mark)

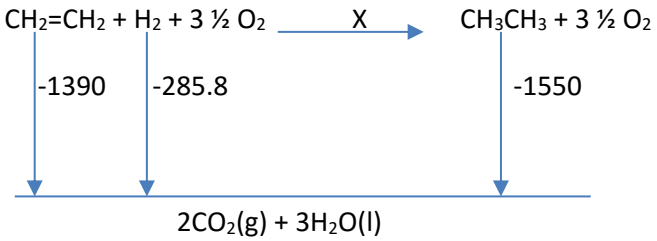
Enthalpy of reaction is enthalpy change when 1 mole of a compound is formed from its reactants at 298K and 1 atmosphere

(c) Calculate the standard enthalpy of hydrogenation of ethene from the data

(i) $C_2H_6(g) + 3\frac{1}{2} O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$ $\Delta H = -1550 kJmol^{-1}$

(ii) $C_2H_4(g) + 3 O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(l)$ $\Delta H = -1390 kJmol^{-1}$

(iii) $H_2(g) + \frac{1}{2} O_2(g) \longrightarrow H_2O(l)$ $\Delta H = -285.8 kJmol^{-1}$ (4marks)



$-1390 + -285.8 = X - 1550$

$X = 125.2 kJmol^{-1}$

3. (a) Aluminium and phosphorus both form compounds in which the oxidation state of the element is +3

(a) Briefly explain in terms of electron structure why aluminium conducts electricity but the common allotropes of phosphorus do not.

The valence electrons of aluminium are delocalized and free to move in the metallic structure while the valence electron do not move

(b) Write equation for the reaction of each of these elements with sodium hydroxide (3mark)

$2Al(s) + 2OH^-(aq) + 6H_2O(l) \rightarrow 2Al(OH)_4^-(aq) + 3H_2(g)$

$P_4(s) + 3OH^-(aq) + 3H_2O(l) \rightarrow PH_3(g) + 3H_2PO_2^-(aq)$

4. Name one reagent that can be used to distinguish between each of the following pairs of compounds and state what would be observed in each case if the reagent is reacted with the compounds;

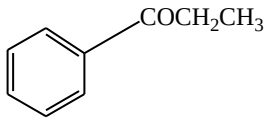
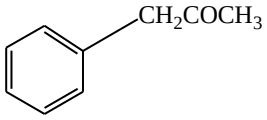
(a) $CH_3CH_2NH_2$ and $(CH_3CH_2)_2NH$ (3marks)

Reagent: **sodium nitrite and hydrochloric acid, <5^{0}C**

Observation:

$CH_3CH_2NH_2$ **effervescence**

$(CH_3CH_2)_2NH$ **yellow oily solid**

(b)  and 

Reagent: **iodine in sodium hydroxide solution**

Observation:

 $COCH_2CH_3$ no observable change

 CH_2COCH_3 yellow precipitate

5. (a) Explain the order of increasing basicity for the following compounds. (2marks)

   $C_6H_5NH_2$ < NH_3 < CH_3NH_2

   Methyl group on CH_3NH_2 donate electrons to nitrogen atom; this increases the electron density of the lone pair of electron that attract hydrogen atom and releases OH^- ions easily. This make methyl amine a stronger base than ammonia

   The phenyl group withdraw electrons to nitrogen atom; this reduces the electron density of the lone pair of electron that make it difficult to attract hydrogen atom from water and make it difficult to releases OH^- ions easily. This makes phenylamine a weaker base than ammonia.

(b) When one mole of methylamine is dissolved in water, the hydrogen ion concentration is found to be 2.5×10^{-10} moldm^{-3}.

(i) Write an equation for the reaction between water and methylamine (1 mark)

$CH_3NH_2(aq) + H_2O(l) \rightarrow CH_3NH_3^+(aq) + OH^-(aq)$

(ii) Calculate the base dissociation constant, Kb, for methylamine. (2 ½ marks)

$[OH^-] = \frac{10^{-14}}{[H^+]} = \frac{10^{-14}}{[2.5 \times 10^{-10}} = 4x10^{-5}$

$Kb = \frac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]} = \frac{[4.5\ X\ 10^{-5}]^2}{1}$ 1.9 X10^{-9}moldm^{-3}

6. The convention of a cell is given below.

$Pt/Fe^{2+}(aq),Fe^{3+}(aq)\ //MnO_4^-(aq),Mn^{2+}(aq),H^+(aq)/Pt$

(a) Write equation for the half-cell reaction at:-

(i) Anode (1mark)

$Fe^{2+}(aq) - e \rightarrow Fe^{3+}(aq)$

(ii) Cathode (1mark)

$MnO_4^-(aq) + 5e + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

(b) Write the overall equation for the cell reaction. (1 ½ marks)

$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l) + 5Fe^{3+}(aq)$

(c) The electrode potentials for the system $Fe^{2+}(aq)/Fe^{3+}(aq)$ and $Mn^{2+}(aq)/MnO_4^-(aq)$ are +0.76V and 1.51V respectively. Deduce whether the reaction in (b) is feasible or not and give a reason for your answer. (2marks)

$E_{cell} = E_{RHE} - E_{LHE} = 1.51 - 0.76 = 0.75V$

7. (a)Define the term boiling point elevation constant of a substance. (1mark)

This is the boiling point elevation caused by 1 mole of a substance in 1000g of solvent

(b) The boiling point of benzene under certain pressure condition is 80.0^0C. Calculate the boiling point elevation constant of benzene, if a solution containing 5g of 2, 4 6-trinitrophenol, ($HOC_6H_2(NO_2)_3$ in 100g of benzene, boils at 80.568^0C. (4marks)

Boiling point elevation 80.586 – 80.0 = 0.586^0C

Mass of 2,4,6-trinitrophenol in 1000g of benzene

100g of benzene contain 5g

1000g of benzene contain $\frac{1000\ x\ 5}{100} = 50g$

Formula mass of 2,4,6-trinitrophenol ($HOC_6H_2(NO_2)_3$ = 229

Boiling point constant, Kb

50 g of 2,4,6-trinitrophenol cause 0.586^0C

229g of 2,4,6-trinitrophenol cause Kb

Kb = $\frac{229\ x\ .586}{50}$ = 2.7^0C

8. 2.00g of phosphorus pentachloride allowed to reach equilibrium at 200^0C in a vessel of $1dm^3$ capacity. If the equilibrium constant of the reaction PCl_5 (g) $\rightleftharpoons$ $PCl_3(g) + Cl_2(g)$ is $0.008moldm^{-3}$ at this temperature and in the conditions stated; calculate the percentage dissociation of phosphorus pentachloride at equilibrium. (4marks)

Formula mass of PCl_5 be 31 + 35.5 x 5 = 208

Mole of PCl_5 = $\frac{2}{208}$ =0.1moles

Let the moles that dissociated be x

Moles of PCl_3 = moles of Cl_2 = x

Moles of PCl5 at equilibrium = 1- x

Kc = $\frac{x^2}{(0.1-x)}$ = 0.008

x =0.025moledm^{-3}

Calculate % dissociation = $\frac{0.025\ x\ 100}{0.1}$ = 25%

9. The first ionization energies of some group II metals of the periodic table and the melting points of their chlorides are given below.

	Mg	Ca	Sr	Ba
First ionization energy /kJmol^{-1}	738	590	549	505
Melting point of chlorides (^{0}C)	708	772	873	967

Explain

(i) Why ionization energy decreases with increase in atomic number. (2marks)

Ionization energy decrease due to decrease in effective nuclear charge. As atomic number increase, the atomic size increase, the distance between the nucleus and outer electrons increase reducing electronegativity.

(ii) Why the melting points of the chlorides of these metals increase with increase in atomic number of the metal. (2marks)

This increases due to increase in the strength of ionic bonds

SECTION B (54 MARKS)

(Attempt any six questions from this section)

10. (a) (i) Define the term "molar conductivity at infinite dilution, Λ_0. (1mark)

This is the conductivity of 1 mole of electrolyte when the solution is very dilute that the ions experience no interaction from other ions.

(ii) State how you would expect the molar conductivity of sodium chloride solution to vary as the dilution of the solution is increased. Give a reason for your answer (2marks)

Molar conductivity of sodium chloride increases linearly with dilution up to the maximum value of molar conductivity at infinity dilution since sodium chloride is a strong electrolyte

(c) The values of Λ_0 at 25^0C for some electrolytes are as follows

Electrolyte	Λ_0/Sm^2mol^{-1}
HCOONa	104.7
NaCl	126.5
HCl	426.2

(i) Calculate Λ_0 at 25^0C for methanoic acid, HCOOH. (2marks)

Λ_0 HCOOH. = Λ_0 HCOONa + Λ_0HC - Λ_0 NaCl

426.2 + 104.7 – 126.5 = 404.4

(ii) If the value of molar conductivity, Λ, for 0.01M methanoic acid is $50.5Sm^2mol^{-1}$ at 25^0C. Calculate the acid dissociation constant, Ka, for methanoic acid. (4marks)

Degree of ionization, $\alpha = \frac{50.5}{404.4} = 0.125$

$Ka = c\alpha^2 = 0.125^2 \times 0.01 = 1.56 \times 10^{-4} moldm^{-3}$

11. (a) (i) Explain the term solubility product. (1mark)

Is a product of molar concentration of ions of a sparingly soluble salt raised to their stoichiometric ratios.

(ii) Write an expression for the solubility product of silver chloride in water (1mark)

$Ks = [Ag^+][Cl^-]$

(b) Ionic conductivity of silver ions and chloride ions at infinite dilution are 6.2 x 10^{-2} and 7.6 x 10^{-2} Sm^2mol^{-1} respectively at 298K. The electrolytic conductivity of silver chloride at 298K is 1.22 x $10^{-2}Sm^2mol^{-1}$.

(i) Calculate the solubility in $moldm^{-3}$ of silver chloride at 298K (3 ½ marks)

$\Lambda_0AgCl = \lambda_0Ag^+(aq) + \lambda_0Cl^-$

= 6.2 x 10^{-2} +7.6 x 10^{-2}

0.138 Sm^2mol^{-1}

$\Lambda_0AgCl = \frac{K}{S}$

Solubility = $\frac{1.22\ x\ 10^{-2}}{0.138}$ 0.0884 molm^3 =0.0000884moldm^{-3}

(ii) Calculate the solubility product, Ksp, of silver chloride at 298K (1 ½ marks)

Ks = $[Ag^+][Cl^-]$ = **0.0000884^2 =7.8 x 10^{-9}mol^{2}dm^{-6}**

(c) State the effect of the following actions on the solubility of silver chloride. Explain your answers.

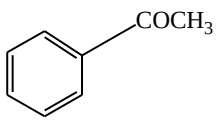
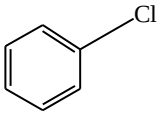
(i) Addition of aqueous ammonia (1mark)

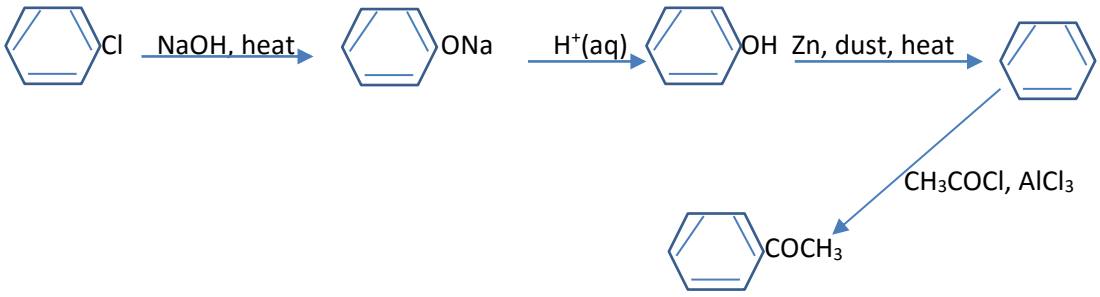
Solubility increases because ammonia form a soluble complex with silver ions shifting solubility equilibrium to the right

(ii) Addition of potassium chromate (VI) solution. (1mark)

Solubility of silver chloride increases because chromate ion form insoluble precipitate with silver ions shifting equilibrium to the right.

12. Write equations to show how the following compounds can be synthesized.

(a)  from  (3½ marks)



(b) $(CH_3)_3COH$ from $(CH_3)_2CHOH$ (2½ marks)

$(CH_3)_2CHOH \xrightarrow{PCl_5} (CH_3)_2CCl \xrightarrow{KCN} (CH_3)_2CCN \xrightarrow{H^+(aq)} (CH_3)_2COOH \xrightarrow[\text{dry ether}]{LiALH_4,} (CH_3)_3CHOH$

(c) $CH_3CH_2CH=CH_2$ from ethyne (3marks)

$HC\equiv CH \xrightarrow{Na,\ Liq.\ NH_3} HC\equiv CNa \xrightarrow{CH_3CH_2Cl} CH_3CH_2C\equiv H \xrightarrow{\text{dry ether, } LiAlH_4} CH_3CH_2CH=CH_2$

13. (a) Explain each of the following observations:

(i) Chromium (III) sulphate dissolves in water to form a solution whose pH is less than seven. (2 ½ marks)

Chromium (III) ions hydrolyze in water to form hydrogen ions

$Cr^{3+}(aq) + 3H_2O(l) \rightarrow Cr(OH)_3(s) + 3H^+(aq)$

(ii) Lead does not form lead (IV) bromide. (2marks)

Probably bromine is not a strong oxidizing agent to oxidize lead (II) ions to lead (IV) ions

(b) To a dilute solution of chromium (III) sulphate was added dilute sodium hydroxide drop wise until in excess followed by 3 drops of hydrogen peroxide and mixture warmed.
State what was observed and use equations to explain the observations. (4 ½ marks)

A green precipitate of chromium (III) oxide reacts with excess OH^- ions to form a green solution of soluble complex which is oxidized to yellow solution of chromium (VI)

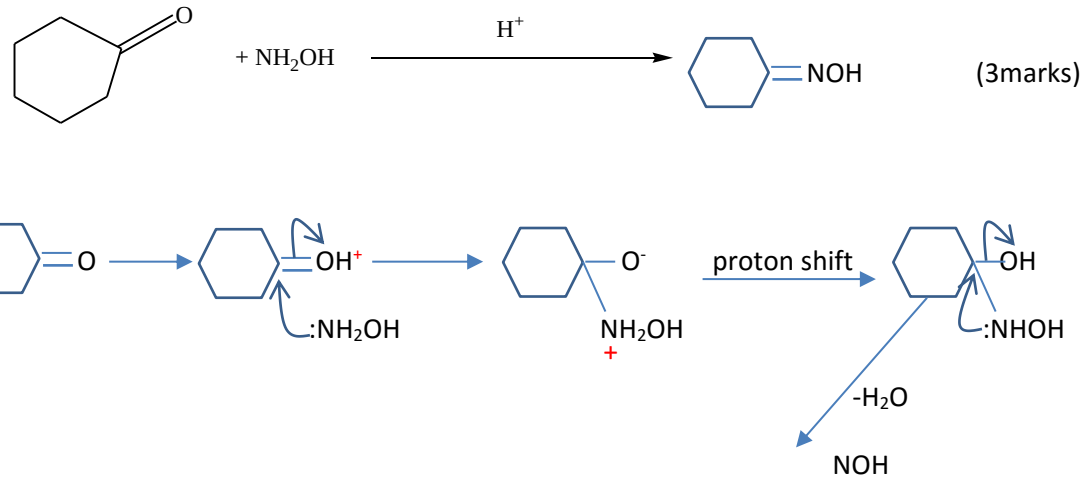
$Cr^{3+}(aq) + 3OH^-(aq) \rightarrow Cr(OH)_3(s)$

$Cr(OH)_3(s) + OH^-(aq) \rightarrow Cr(OH)_4^-(aq)$

$2Cr(OH)_4^-(aq) + 3H_2O_2(aq) + 2OH^-(aq) \rightarrow 2CrO_4^{2-}(aq) + 8H_2O(l)$

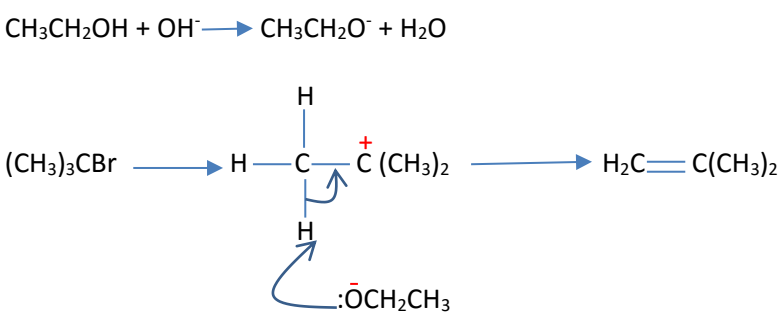
14. Complete the following equations and in each case write a mechanism for the reaction.

(a)

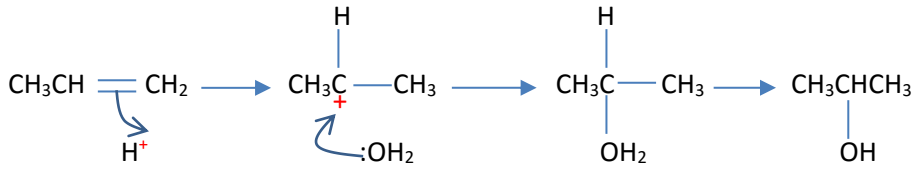


(3marks)

(b) $(CH_3)_3CBr \xrightarrow[C_2H_5OH,\ Heat]{NaOH} (CH_3)_2C{=}CH_2$ (3marks)



(c) $CH_3CH{=}CH_2 + CocH_2SO_4 \xrightarrow[\text{warm}]{H_2O} CH_3CHCH_3$ (OH) (3marks)



15. Vegetable oils have great economic and social importance

(a)(i) Explain what is meant by the term vegetable oils (1mark)

Oil obtained from plant seeds

(ii) Name two main sources of vegetable oils. (1mark)

Sun flower seeds

Cotton seed

Castor oil seed

(iii) Describe briefly how vegetable oil can be obtained on a large scale from one of the sources you have named in (a)(i) above. (technical details are not required) (2marks)

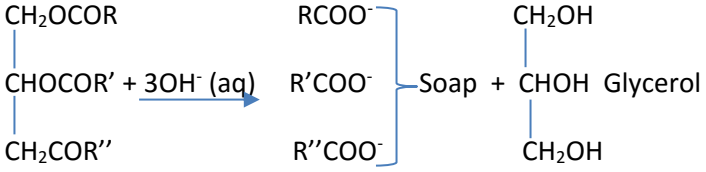
Seeds are crashed and oil obtained by solvent extraction.

(b) (i) State the name given to the reaction leading to the formation of soap from oil. (1mark)

Saponification

(ii) Write a general equation for the formation of soap from oil. (1mark)

(iii)



(iv) Outline how soap is manufactured, (technical details not required). (3marks)

Vegetable oil is boiled with sodium hydroxide for some time, concentrated sodium chloride solution is added to precipitate soap. On cooling soap is skimmed off the mixture.

16. State what would be observed and write the equation for the reaction that would take place when:

(a) Hydrogen sulphide gas is passed through an acidified solution of potassium dichromate (VI).

Observation (2 ½ mark)

Orange solution turns green with formation of yellow solid

Equation:

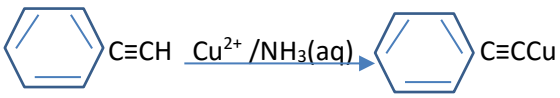
$Cr_2O_7^{2-} + 3H_2S(g) + 8H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3S(s) + 7H_2O(l)$

(b) 2,3 drops of ammoniacal copper (I) chloride is added to phenylethyne. (2marks)

Observation

Red precipitate

Equation:



(c) Neutral iron (III) chloride solution is added to 1 cm^3 of propanoic acid (2marks)

Observation

Red solution

Equation:

$3CH_3CH_2COO^- + Fe^{3+}(aq) \rightarrow (CH_3CH_2COO)_3Fe$

(d) A spatula end ful of sodium hydrogen carbonate is added to iron (III) chloride solution (2 ½ marks)

Observation

Effervescence and brown precipitate

Equation:

$2Fe^{3+}(aq) + 3CO_3^{2-} + 3H_2O(l) \rightarrow 2Fe(OH)_3(s) + 3CO_2(g)$

17. (a) Fluorine is the first member of the halogen group of elements in the periodic table and it shows anomalous behavior among the halogens.

(i) State **three** major differences between fluorine and other halogens. (2½ marks)

Reacts with water to liberate oxygen

Reacts with concentrated sodium hydroxide solution to liberate oxygen

Reacts with carbon, SiO_2

(ii) Give **three** causes for the anomalous behavior of fluorine. (3mmarks)

Has small atomic radius

Has high electronegativity

Has very low F-F bond energy

Forms strong bonds with other elements

(c) The acid dissociation constants Ka for the hydrides of elements of group (VII) elements are given in the table below:

Hydride	HF	HCl	HBr	HI
Ka ($moldm^{-3}$)	5.6×10^{-11}	1×10^{-9}	1×10^{-7}	1×10^{-4}

State and explain the trend in variation of acid strength of the hydrides (4marks)

Acid strength decrease from HI>HBr>HCl>HF due to increase in H-X bond strength HI<HBr<HCl<HF

1	2											3	4	5	6	7	8
1.0 H 1																1.0 H 1	4.0 He 2
6.9 Li 3	9.0 Be 4											10.8 B 5	12.0 C 6	14.0 N 7	16.0 O 8	19.0 F 9	20.2 Ne 10
23.0 Na 11	24.3 Mg 12											27.0 Al 13	28.1 Si 14	31.0 P 15	32.1 S 16	35.4 Cl 17	40.0 Ar 18
39.1 K 19	40.1 Ca 20	45.0 Sc 21	47.9 Ti 22	50.9 V 23	52.0 Cr 24	54.9 Mn 25	55.8 Fe 26	58.9 Co 27	58.7 Ni 28	63.5 Cu 29	65.7 Zn 30	69.7 Ga 31	72.6 Ge 32	74.9 As 33	79.0 Se 34	79.9 Br 35	83.8 Kr 36
85.5 Rb 37	87.6 Sr 38	88.9 Y 39	91.2 Zr 40	92.9 Nb 41	95.9 Mo 42	98.9 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	139 La 57	178 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	207 Ti 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															

			139 La 57	140 Ce 58	141 Pr 59	144 Nd 60	147 Pm 61	150 Sm 62	152 Eu 63	157 Gd 64	159 Tb 65	162 Dy 66	165 Ho 67	167 Er 68	169 Tm 69	173 Yb 70	175 Lu 71
			227 AC 89	232 Th 90	231 Pa 91	238 U 92	237 Np 93	244 Pu 94	243 Am 95	247 Cm 96	247 Bk 97	251 Cf 98	254 Es 99	257 Fm 100	256 Md 101	254 No 102	260 Lw 103

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