

නව නිර්දේශය/புதிய பாடத்திட்டம்/New Syllabus

NEW ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව
 இலங்கைப் பரீட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம்
 Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2020
 கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2020
 General Certificate of Education (Adv. Level) Examination, 2020

රසායන විද්‍යාව II
 இரசாயனவியல் II
 Chemistry II

සමස්ත කාලය/கலவை நேரம்/Total Time
 02:00:00

02 E II

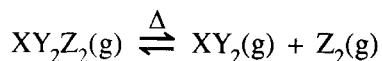
* Universal gas constant $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$

* Avogadro constant $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

PART B — ESSAY

Answer two questions only. (Each question carries 150 marks.)

5. (a) A compound $\text{XY}_2\text{Z}_2(\text{g})$ undergoes dissociation when heated to temperatures above 300 K as given below.



A sample of 7.5 g of $\text{XY}_2\text{Z}_2(\text{g})$ was placed in an evacuated 1.00 dm^3 rigid-closed container and the temperature was raised to 480 K.

Molar mass of $\text{XY}_2\text{Z}_2(\text{g})$ is 150 g mol^{-1} . Use the approximate value of 4000 J mol^{-1} for RT at 480 K. Assume ideal gas behaviour for all gases.

- Calculate the number of moles of $\text{XY}_2\text{Z}_2(\text{g})$ in the container before dissociation.
 - When the above system reaches equilibrium at 480 K, the total number of moles in the container was found to be $7.5 \times 10^{-2} \text{ mol}$. Calculate the number of moles of $\text{XY}_2\text{Z}_2(\text{g})$, $\text{XY}_2(\text{g})$ and $\text{Z}_2(\text{g})$ in the equilibrium mixture at 480 K.
 - Calculate the equilibrium constant K_c for the above reaction at 480 K.
 - Calculate K_p for the equilibrium at 480 K. (75 marks)
- (b) For the reaction $\text{XY}_2\text{Z}_2(\text{g}) \rightarrow \text{XY}_2(\text{g}) + \text{Z}_2(\text{g})$ described in (a), Gibbs free energies (G) at 480 K for $\text{XY}_2\text{Z}_2(\text{g})$, $\text{XY}_2(\text{g})$ and $\text{Z}_2(\text{g})$ are -60 kJ mol^{-1} , -76 kJ mol^{-1} and -30 kJ mol^{-1} , respectively.
- Calculate ΔG (in kJ mol^{-1}) for the reaction at 480 K.
 - The magnitude of ΔS of the above reaction is $150 \text{ J K}^{-1} \text{ mol}^{-1}$ at 480 K. Calculate ΔH for the reaction at 480 K by using the appropriate sign (– or +) of ΔS .
 - By using the sign (– or +) of ΔH obtained in (ii), explain whether this reaction is exothermic or endothermic.
 - Deduce the enthalpy difference for the formation of $\text{XY}_2\text{Z}_2(\text{g})$ from $\text{XY}_2(\text{g})$ and $\text{Z}_2(\text{g})$ at 480 K.
 - If the bond enthalpy of the X–Z bond in $\text{XY}_2\text{Z}_2(\text{g})$ is $+250 \text{ kJ mol}^{-1}$, calculate the bond enthalpy of the Z–Z bond.
 (Assume that $\text{XY}_2\text{Z}_2(\text{g})$ has the structure $\text{Z}-\overset{\text{Y}}{\underset{\text{Y}}{\text{X}}}-\text{Z}$)
 - If liquid XY_2Z_2 is used instead of gaseous XY_2Z_2 , giving reasons, explain whether the value of ΔH obtained for the reaction $\text{XY}_2\text{Z}_2(\text{l}) \rightarrow \text{XY}_2(\text{g}) + \text{Z}_2(\text{g})$ is equal to, or higher or lower than ΔH obtained in (ii). (75 marks)

6. (a) Consider the reaction given below occurring in a closed container at a given temperature T .

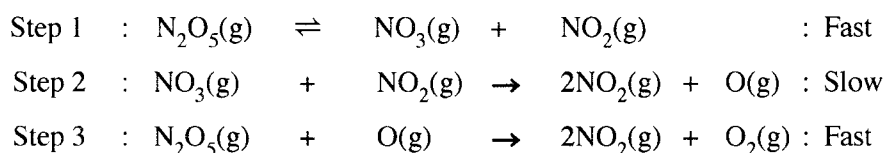


- (i) Write **three** expressions for the rate of reaction relevant to each of the compounds appearing in the reaction.
- (ii) This reaction was carried out at temperature T with an initial concentration of 0.10 mol dm^{-3} of $\text{N}_2\text{O}_5(\text{g})$. It was found that 40% of the initial amount was decomposed after a period of 400 s.
 - I. Calculate the average rate of decomposition of $\text{N}_2\text{O}_5(\text{g})$ in this time interval.
 - II. Calculate average rates of formation of $\text{NO}_2(\text{g})$ and $\text{O}_2(\text{g})$.
- (iii) In another experiment, initial rates were measured for this reaction at 300 K and the results are given below.

$[\text{N}_2\text{O}_5(\text{g})] / \text{mol dm}^{-3}$	0.01	0.02	0.03
Initial rate / $\text{mol dm}^{-3} \text{ s}^{-1}$	6.930×10^{-5}	1.386×10^{-4}	2.079×10^{-4}

Derive the rate law for the reaction at 300 K.

- (iv) Another experiment was carried out at 300 K with an initial concentration of 0.64 mol dm^{-3} of $\text{N}_2\text{O}_5(\text{g})$. It was found that the concentration of $\text{N}_2\text{O}_5(\text{g})$ which remained after a period of 500 s was $2.0 \times 10^{-2} \text{ mol dm}^{-3}$.
 - I. Calculate the half-life ($t_{1/2}$) of the reaction at 300 K.
 - II. Calculate the rate constant of the reaction at 300 K.
- (v) This reaction proceeds through a mechanism involving the following elementary steps.



Show that the above mechanism is consistent with the rate law of the reaction. (80 marks)

- (b) An ideal binary-liquid mixture was prepared by mixing two liquids of **A** and **B** in a closed evacuated container at temperature T . After establishing the equilibrium at temperature T , partial pressures of **A** and **B** in the vapour phase are P_{A} and P_{B} , respectively. At temperature T , the saturated vapour pressures of **A** and **B** are P_{A}° and P_{B}° , respectively. Mole fractions of **A** and **B** in solution are X_{A} and X_{B} , respectively.

- (i) Show that $P_{\text{A}} = P_{\text{A}}^{\circ} X_{\text{A}}$
(Consider that the rates of vaporization and condensation are equal at equilibrium.)
- (ii) In the above system at 300 K, the total pressure was $5.0 \times 10^4 \text{ Pa}$. The saturated vapour pressures of pure **A** and **B** at 300 K, are $7.0 \times 10^4 \text{ Pa}$ and $3.0 \times 10^4 \text{ Pa}$, respectively.
 - I. Calculate the mole fraction of **A** in the liquid phase of the equilibrium mixture.
 - II. Calculate the vapour pressure of **A** in the equilibrium mixture.

(70 marks)

7. (a) (i) To compare the properties of Electrolytic and Galvanic cells, copy and complete the following table using the given terms.

Terms: anode, cathode, positive, negative, spontaneous, non-spontaneous.

	Electrolytic cell	Galvanic cell
A. Oxidation half-reaction takes place at		
B. Reduction half-reaction takes place at		
C. Sign of E_{cell}°		
D. Electron flow	From to	From to
E. Spontaneity of the cell reaction		

- (ii) An electrochemical cell was constructed at 300 K by using a Zn(s) anode, an aqueous alkaline electrolyte and a porous Pt cathode which facilitates the collection of oxygen $\text{O}_2(\text{g})$ from air as shown below. As the cell operates ZnO(s) is produced.

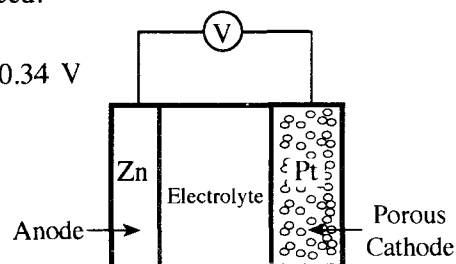
You are given that

$$E_{\text{ZnO(s)}|\text{Zn(s)}|\text{OH}^-(\text{aq})}^{\circ} = -1.31 \text{ V and } E_{\text{O}_2(\text{g})|\text{OH}^-(\text{aq})}^{\circ} = +0.34 \text{ V}$$

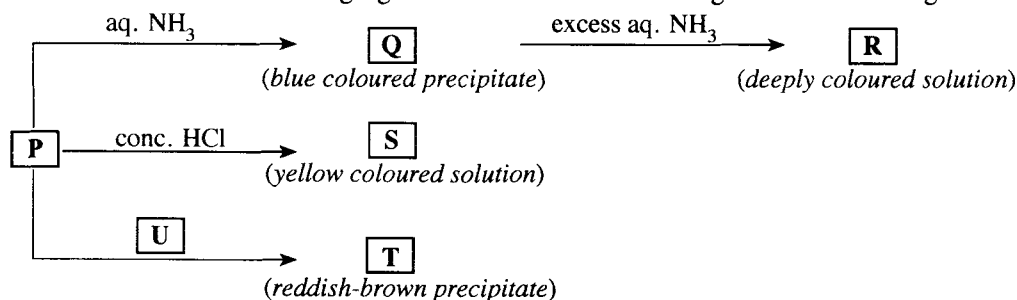
$$\text{Zn} = 65 \text{ g mol}^{-1}, \text{O} = 16 \text{ g mol}^{-1} \text{ and}$$

$$1 F = 96,500 \text{ C}$$

- Write the half-reactions occurring at anode and cathode.
- Write the overall cell reaction.
- Calculate the cell potential E_{cell}° at 300 K.
- State the direction of migration of $\text{OH}^-(\text{aq})$ ions between the electrodes.
- When the cell operates for a period of 800 s at 300 K, 2 mol of $\text{O}_2(\text{g})$ are consumed.
 - Calculate the number of moles of electrons passing through the cell.
 - Calculate the mass of ZnO(s) formed.
 - Calculate the current passing through the cell.



- (b) A coloured complex ion **P** is formed when the salt $\text{M}(\text{NO}_3)_n$ is dissolved in distilled water. **M** is a transition element belonging to the 3d block. **P** undergoes the following reactions.



T and **U** are coordination compounds each containing four elements. **P**, **R** and **S** are complex ions.

- Identify the metal **M**. Give the oxidation state of **M** in complex ion **P**.
- Give the value of n in $\text{M}(\text{NO}_3)_n$.
- Write the complete electronic configuration of **M** in complex ion **P**.
- Write the chemical formulae of **P**, **Q**, **R**, **S**, **T** and **U**.
- Give the IUPAC names of **P**, **R**, **S**, **T** and **U**.
- What is the colour of **P**?
- What would you expect to observe in I and II given below?
 - When H_2S gas is passed into an acidic solution containing **P** at room temperature
 - When the mixture obtained in I above is heated with dilute HNO_3 after the removal of dissolved H_2S
- Briefly describe a method with the aid of balanced chemical equations for determining the concentration of M^{n+} present in an aqueous solution, using the following chemicals.

KI, $\text{Na}_2\text{S}_2\text{O}_3$ and starch.

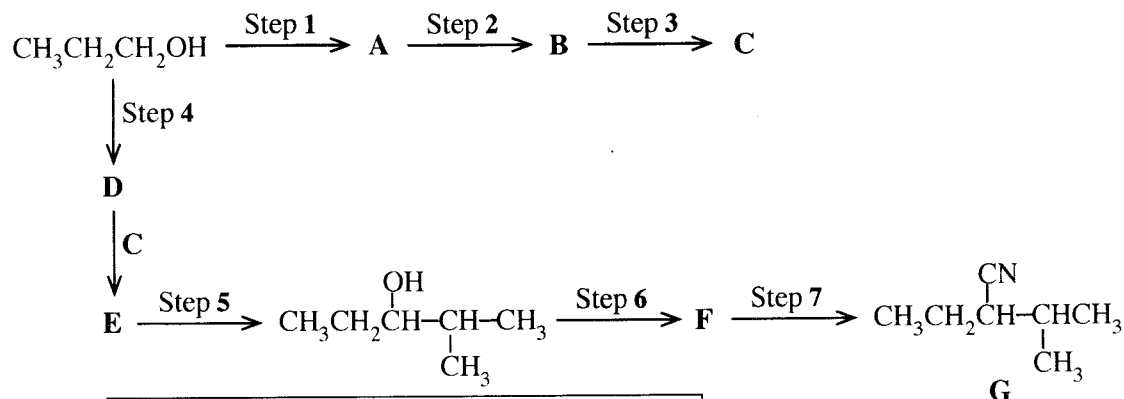
(75 marks)

[see page twelve]

PART C — ESSAYAnswer **two** questions only. (Each question carries **150 marks**.)

8. (a) (i) Given below is a reaction scheme for the synthesis of compound **G** using $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ as the only organic starting compound.

Complete the reaction scheme by drawing the structures of compounds **A**, **B**, **C**, **D**, **E** and **F** and writing the appropriate reagents for steps 1 – 7, selected only from those given in the list.

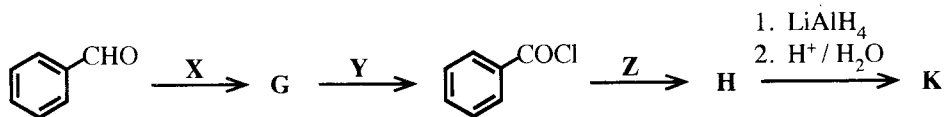
**List of Reagents**

HBr, PBr_3 , pyridiniumchlorochromate (PCC),
Mg / dry ether, KCN, conc. H_2SO_4 , dil. H_2SO_4

(52 marks)

- (ii) Consider the following series of reactions.

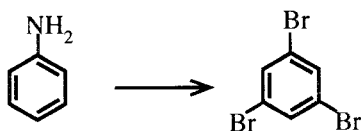
Draw the structures of compounds **G**, **H** and **K**. Give the reagents **X**, **Y** and **Z**.



Note that **K** gives benzyl alcohol ($\text{C}_6\text{H}_5\text{CH}_2\text{OH}$) when reacted with NaNO_2 / dil. HCl .

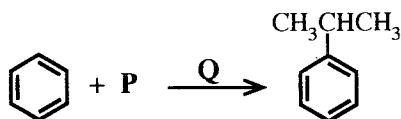
(24 marks)

- (b) (i) Show how the following conversion could be carried out in **not more than three** steps.



(20 marks)

- (ii) Consider the following reaction.



Identify the chemical substances **P** and **Q** necessary to carry out this reaction.

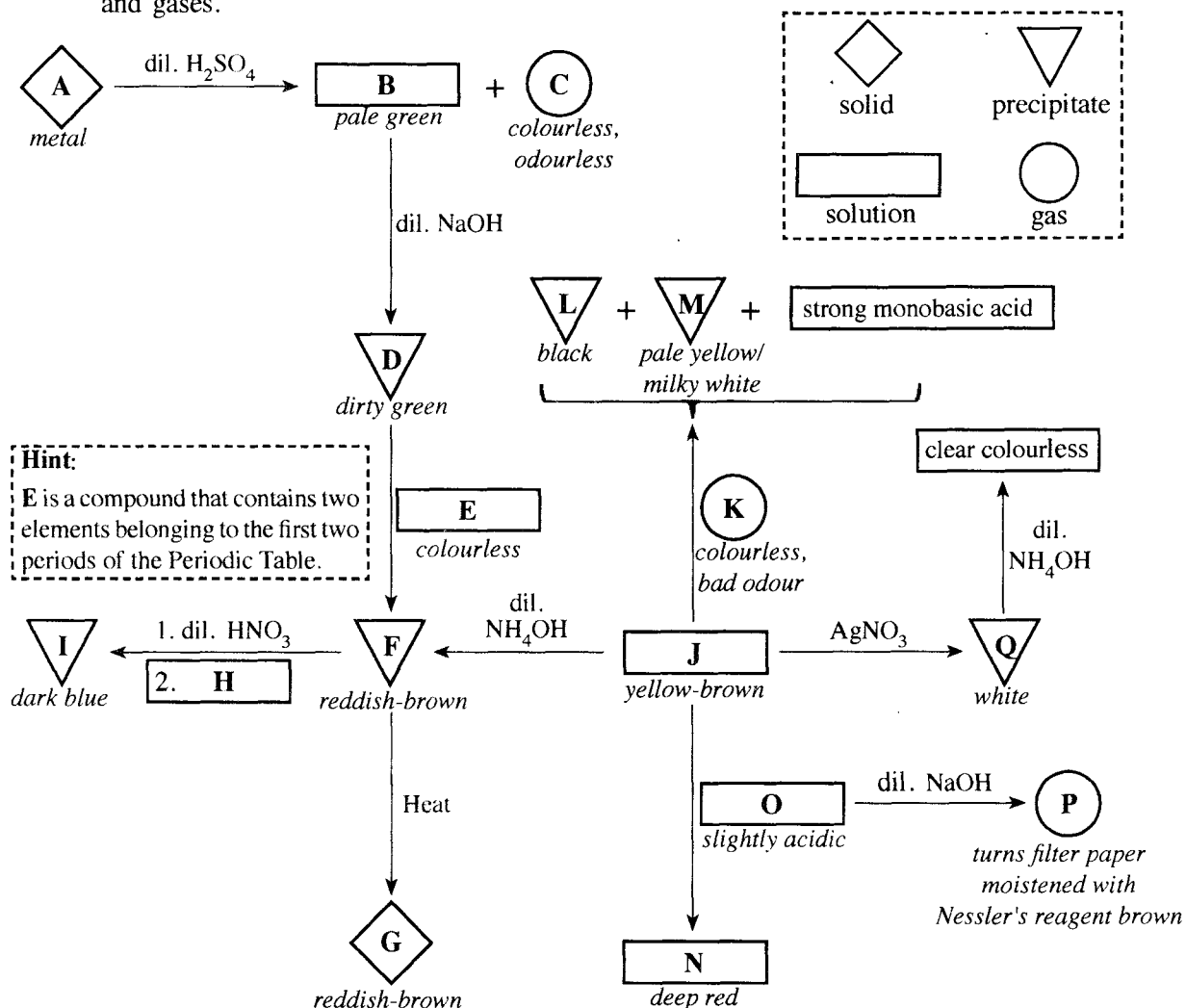
Write the mechanism of this reaction.

(20 marks)

- (c) (i) Explain why phenol is more reactive in electrophilic substitution reactions than benzene, by considering their resonance hybrids.
- (ii) Illustrate the difference in reactivity between phenol and benzene as given in (i) above by means of a suitable reaction.
- (iii) Draw the structure(s) of product(s) you described in the reaction in (ii) above.

(34 marks)

9. (a) (i) Write the chemical formulae of the substances A – Q given in the flow chart below.
(Note: Chemical equations and reasons are not expected for the identification of substances A – Q.)
The symbols given in the box (dash lines) are used to represent solids, precipitates, solutions and gases.



- (ii) Write the complete electronic configuration of A.
- (iii) State the function of E in the conversion of D to F. Give the relevant balanced chemical equations for the stated function. (75 marks)
- (b) The solid X contains only Cu_2S and CuS . The following procedure was used to determine the percentage of Cu_2S in X.

Procedure

A 1.00 g portion of solid X was treated with 100.00 cm^3 of $0.16 \text{ mol dm}^{-3} \text{ KMnO}_4$ in dilute H_2SO_4 medium. This reaction gave Mn^{2+} , Cu^{2+} and SO_4^{2-} as products. Thereafter, the excess KMnO_4 in this solution was titrated with $0.15 \text{ mol dm}^{-3} \text{ Fe}^{2+}$ solution. The volume required for the titration was 35.00 cm^3 .

- (i) Write the balanced ionic equations for the reactions taking place in the above procedure.
- (ii) Based on the answers to (i) above, determine the molar ratio between,
- Cu_2S and KMnO_4
 - CuS and KMnO_4
 - Fe^{2+} and KMnO_4

(iii) Calculate the percentage by weight of Cu_2S in X. (Cu = 63.5, S = 32)

(75 marks)

[see page fourteen]

10. (a) The following questions are based on the properties of titanium dioxide (TiO_2) and its manufacture carried out by the "Chloride Process".

- (i) Name the raw materials used in this process.
- (ii) Briefly describe the manufacturing process of TiO_2 giving balanced chemical equations where applicable.
- (iii) State **three** properties of TiO_2 and give one use each, relevant to each property.
- (iv) If you were to consider establishing a TiO_2 manufacturing plant in Sri Lanka, state **three** requirements that need to be fulfilled.
- (v) Does the manufacturing process described in (ii) above contribute to global warming? Justify your answer. (50 marks)

(b) Currently, global warming due to change in greenhouse effect is significantly greater than that before the industrial revolution.

- (i) Explain briefly what is meant by greenhouse effect.
- (ii) Identify the major environmental problem that occurs due to global warming.
- (iii) State **two main** natural gases that contribute to global warming.
- (iv) Explain briefly how microorganisms contribute to the release of the gases you stated in (iii).
- (v) In addition to the gases you stated in (iii), name **two** classes of synthetic volatile compounds that directly contribute to the global warming, and selecting one compound from each class, draw their structures.
- (vi) Select **one** class of compounds from the two classes you stated in (v) that contributes to the catalytic degradation of ozone in the upper atmosphere.
- (vii) The slow down of industrial activities due to the Covid-19 pandemic temporarily eased the global environmental issues in many countries. Justify this statement by using **two** main global environmental issues you have learnt. (50 marks)

(c) The following questions are based on the polymers given below.

Polyvinyl chloride (PVC), Polyethylene (PE), Polystyrene (PS), Bakelite,
Nylon 6.6, Polyethylene terephthalate (PET), Gutta percha

- (i) Draw the repeating units of **four** of the above polymers.
- (ii) Categorize each of the above seven (7) polymers as either,
 - I. natural or synthetic polymers.
 - II. addition or condensation polymers.
- (iii) Name the **two** monomers used in the formation of bakelite.
- (iv) Polymers can be grouped into two categories based on their thermal properties. State these **two** categories. Write to which of these categories PVC and bakelite belong.
- (v) Give **one** use each for **three** of the polymers given in the above list. (50 marks)

* * *

The Periodic Table

	1																	2
1	H																	He
	3	4											5	6	7	8	9	10
2	Li	Be											B	C	N	O	F	Ne
	11	12											13	14	15	16	17	18
3	Na	Mg											Al	Si	P	S	Cl	Ar
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
	55	56	La-	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
6	Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
	87	88	Ac-	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
7	Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr