



**UNIVERSITI KUALA LUMPUR**  
**MALAYSIAN INSTITUTE OF CHEMICAL AND BIOENGINEERING TECHNOLOGY**

---

## **FINAL EXAMINATION**

## **JANUARY 2026 SEMESTER**

---

**COURSE CODE** : CLB10803

**COURSE NAME** : ANALYTICAL & ORGANIC CHEMISTRY

**PROGRAMME NAME** : TECHNICAL FOUNDATION - BACHELOR

**DATE** : 26 JANUARY 2026

**TIME** : 2:00PM – 5:00PM

**DURATION** : 3 HOURS

---

### **INSTRUCTIONS TO CANDIDATES**

---

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. This question booklet consists of TWO sections.
4. Answer ALL questions for Section A.
5. Section B consists of four questions. Answer THREE (3) questions only.
6. Please write your answer on the answer booklet provided and answer all questions in English only.
7. FTIR table and periodic table are appended.

---

**THERE ARE 11 PAGES OF QUESTIONS, INCLUDING THIS PAGE.**

---



## SECTION A (Total: 40 marks)

INSTRUCTION: Answer ALL questions.

Please use the answer booklet provided.

## Question 1

Benzene reacts with nitric acid ( $\text{HNO}_3$ ) in the presence of  $\text{H}_2\text{SO}_4$  to give a major product (Compound A).

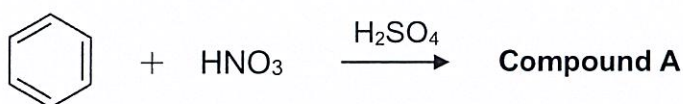


Figure 1: Nitration reaction

- (a) Predict the structural formula of the major product (Compound A) formed in the nitration reaction.  
(2 marks)
- (b) Compound A is then reacted with  $\text{Br}_2$  in the presence of  $\text{FeBr}_3$ . Predict the structural formula for the major product (Compound B).  
(2 marks)
- (c) State the IUPAC name of Compound B.  
(2 marks)
- (d) Describe the directing effects of functional group to the benzene ring.  
(2 marks)
- (e) Fourier infrared (FTIR) spectroscopy is used to distinguish Compound A and Compound B. For each compound, state the important IR absorption regions expected for each compound that show their structural differences.  
(6 marks)
- (f) Predict which compound (Compound A or Compound B) has the higher boiling point and justify the answer with three reasons.  
(6 marks)

## Question 2

A wastewater treatment plant monitors dye contamination. Methylene blue (a common dye) absorbs strongly at  $\lambda = 664$  nm. A series of standard solutions and one wastewater sample were analyzed by ultraviolet-visible (UV-Vis) spectrophotometer.

Table 1: Absorbance of methylene blue standard solutions and unknown sample

| Sample     | Concentration (ppm) | Absorbance |
|------------|---------------------|------------|
| Standard 1 | 1.0                 | 0.082      |
| Standard 2 | 2.0                 | 0.162      |
| Standard 3 | 3.0                 | 0.242      |
| Standard 4 | 4.0                 | 0.322      |
| Standard 5 | 5.0                 | 0.402      |
| Sample Y   | ?                   | 0.277      |

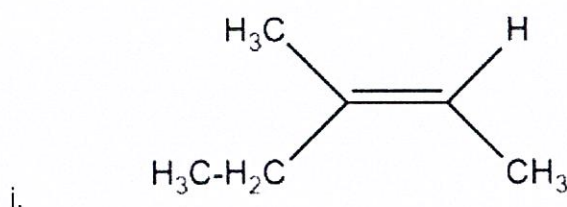
- (a) i. Using the calibration data in Table 1, determine the concentration (ppm) of methylene blue in Sample Y.

(6 marks)

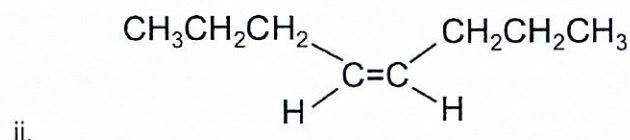
- ii. State FOUR (4) advantages of using UV-Vis spectrophotometer for analyzing colored pollutants in wastewater.

(4 marks)

- (b) Give the IUPAC name for the following compounds.



(2 marks)



(2 marks)

- (c) A soft drink sample containing tartrazine (yellow food dye) is analyzed using a UV-Vis spectrophotometer at 427 nm. The cuvette path length is 1.0 cm, the molar absorptivity ( $\epsilon$ ) of tartrazine is  $1.2 \times 10^3 \text{ L}\cdot\text{mol}^{-1}\cdot\text{cm}^{-1}$ , and the solution concentration is  $5.0 \times 10^{-4} \text{ M}$ .

i. Calculate the absorbance (A) of the solution.

(3 marks)

ii. Calculate the % transmittance (%T) of the solution.

(3 marks)

## SECTION B (Total: 60 marks)

INSTRUCTION: Answer only THREE questions.

Please use the answer booklet provided.

## Question 3

In the esterification reaction, propan-1-ol is reacted with ethanoic acid, in the presence of sulphuric acid.

- (a) i. With the aid of chemical equation, predict the product/s of the reaction. (4 marks)
- ii. Give the IUPAC name of the major product in the reaction in Question 3 (a)(i). (2 marks)
- iii. The major product obtained in Question 3(a)(ii), has been analyzed using Fourier transform infrared (FTIR) spectroscopy. By referring to the table given in Appendix I, identify the possible functional groups present in the FTIR spectra as shown in Figure 2 and state the frequency.

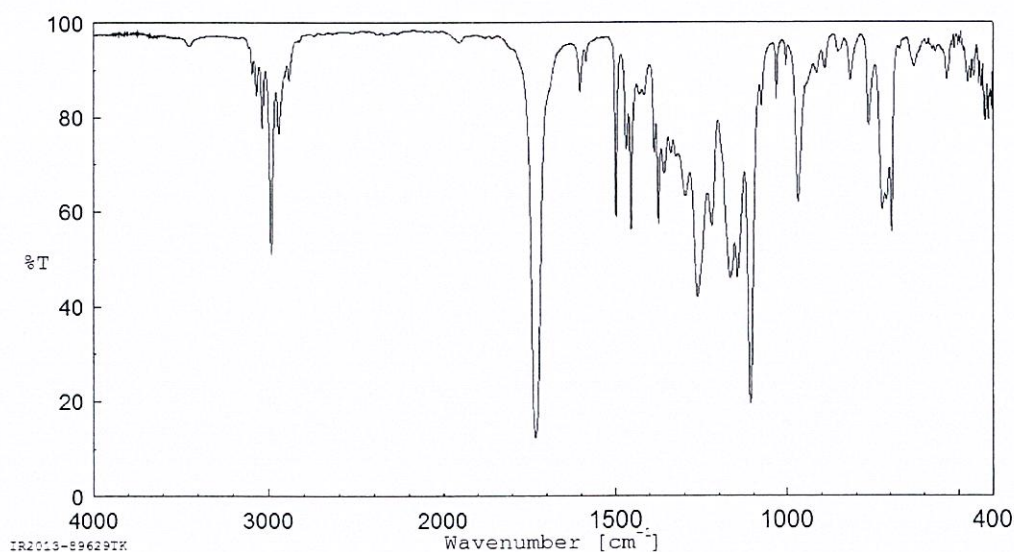


Figure 2: FTIR spectra

(4 marks)

(b) Draw the structural formula of the following compounds.

- i. N-ethylbutanamide (2 marks)
- ii. N-methyl-N-isopropylpentanamine (2 marks)
- iii. N-ethyl-N-methylaniline (2 marks)
- iv. 2-methyl-2-octanamine (2 marks)
- v. Cyclopentanamine (2 marks)

#### Question 4

2-methyl-2-butanol is heated with concentrated sulfuric acid ( $\text{H}_2\text{SO}_4$ ), a dehydration reaction occurs.



Figure 3: Schematic reaction of alcohol

- (a) Predict the structural formula of the major product (Compound A) yielded by this chemical reaction. (4 marks)
- (b) State the IUPAC name of Compound A and Compound B. (4 marks)
- (c) Compound A reacts with hydrobromic acid (HBr), an addition reaction takes place. Draw the structural formula of Compound C.

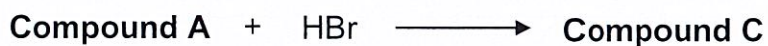


Figure 4: Schematic of addition reaction

(2 marks)

- (d) Predict rules that applied in the formation of Compound A and Compound C. (2 marks)
- (e) Compare the boiling points of 2-methyl-2-butanol, Compound A, and Compound C. (4 marks)
- (f) Fourier transform infrared (FTIR) spectroscopy is used to distinguish Compounds A, B, and C. Describe the key IR absorption regions expected for each compounds. (4 marks)

### Question 5

The diagram below shows the basic components of an atomic absorption spectroscopy (AAS) used for elemental analysis.

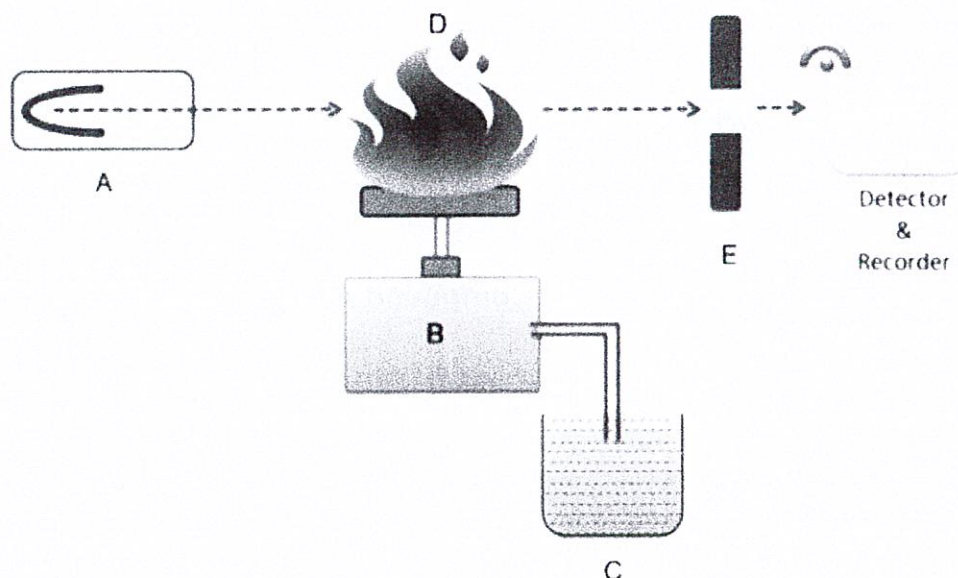


Figure 5: Schematic diagram of AAS

- (a) Identify the components A, B, C, D and E in the AAS diagram. (5 marks)
- (b) State THREE (3) of differences between a flame atomizer and a graphite furnace atomizer in AAS. (6 marks)
- (c) You receive industrial samples containing an organic compound and are asked to determine the functional groups. Explain whether AAS is suitable for this analysis. (4 marks)

- (d) You are required to analyze an unsaturated organic compound. Suggest suitable analytical equipment that can be used for this purpose.

(2 marks)

- (e) Explain your choice in Question 5 (d).

(3 marks)

### Question 6

A calibration curve in Figure 6 below is used for the analysis of caffeine in energy drinks.

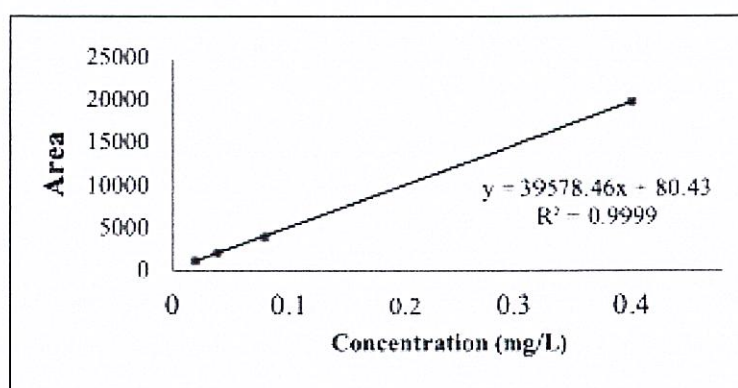


Figure 6: Calibration of caffeine standard solution

- (a) Calculate the concentration of caffeine in sample A and B if the area are 4007.0 and 19844, respectively.

(4 marks)

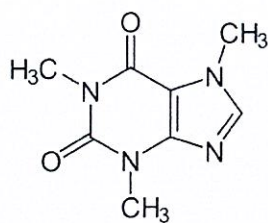
- (a) The analysis of caffeine in carbonated drink is using two types of solvent as mobile phase. State the function of mobile phase used in caffeine analysis.

(2 marks)

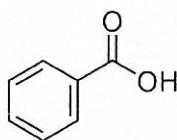
- (b) Give FOUR (4) comparison between high performance liquid chromatography (HPLC) and gas chromatography (GC).

(8 marks)

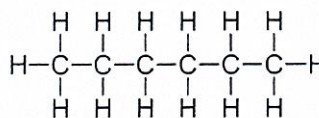
- (d) Caffeine, benzoic acid and hexane as shown in Figure 7 are analyzed using reversed-phase HPLC.



Caffeine



Benzoic acid



Hexane

Figure 7: The chemical structure of caffeine, benzoic acid and hexane

- i. Based on the chemical structures, arrange these compounds in order of increasing retention time. (3 marks)
- ii. Explain the answer of Question 6 (d)(i). (3 marks)

**END OF EXAMINATION QUESTION**

## APPENDIX I

**IR Absorption Correlation Chart**

| Bond         | Compound Type                                | Frequency range, cm <sup>-1</sup> |
|--------------|----------------------------------------------|-----------------------------------|
| C-H          | Alkynes                                      | 3333-3267 (s) stretching          |
|              | Alkenes                                      | 3100-3000 (m) stretching          |
|              | Alkanes                                      | 3000-2840 (m) stretching          |
|              | Aldehydes                                    | 2830-2695 (m, doublet) stretching |
| C-H          | Alkanes                                      | 1365-1465 (m) bending             |
|              | Aldehydes                                    | 1390-1380 (m) bending             |
|              | Aromatic compounds                           | 2000-1650 (w) bending             |
| C-C          | Alkanes                                      | Below 1200 (variables)            |
| C=C          | Alkenes                                      | 1680-1600 (m,w) stretching        |
| C=C          | Aromatic Rings                               | 1600, 1500 (w) stretching         |
| C $\equiv$ C | Alkynes                                      | 2260-2100 (w,sh) stretching       |
| C-O          | Alcohols, Ethers, Carboxylic acids, Esters   | 1260-1000 (s) stretching          |
| C=O          | Aldehydes, Ketones, Carboxylic acids, Esters | 1810-1670 (s) stretching          |
| O-H          | Alcohols, Phenols                            | 3640-3160 (s, br) stretching      |
|              | Carboxylic acids                             | 3000-2500 (br) stretching         |
| O-H          | Alcohols                                     | 1420-1330 (m) bending             |
|              | Carboxylic acids                             | 1440-1395 (m) bending             |
| N-H          | Amines                                       | 3500-3300 (m, sh) stretching      |
| C-N          | Amines                                       | 1340-1020 (m) stretching          |
| C $\equiv$ N | Nitriles                                     | 2260-2220 (v) stretching          |
| C-Cl         | Halogen compounds                            | 850-550 (s) stretching            |
| C-Br         |                                              | 690-515 (s) stretching            |
| C-I          |                                              | 600-500 (s) stretching            |

v - variable, m - medium, s - strong, w - weak, br - broad, sh - sharp

|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 |                                     |
|---------------------------------|---------------------------------|--------------------------------|-------------------------------------|---------------------------------|----------------------------------|----------------------------------|---------------------------------|----------------------------------|------------------------------------|-----------------------------------|-----------------------------------|---------------------------------|---------------------------------|---------------------------------|-----------------------------------|----------------------------------|---------------------------------|-------------------------------------|
| 1<br>H<br>Hydrogen<br>1.008     |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  | 2<br>He<br>Helium<br>4.003      |                                     |
| 3<br>Li<br>Lithium<br>6.941     | 4<br>Be<br>Beryllium<br>9.012   |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 10<br>Ne<br>Neon<br>20.180          |
| 11<br>Na<br>Sodium<br>22.990    | 12<br>Mg<br>Magnesium<br>24.305 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 18<br>Ar<br>Argon<br>39.948         |
| 19<br>K<br>Potassium<br>39.098  | 20<br>Ca<br>Calcium<br>40.078   | 21<br>Sc<br>Scandium<br>44.955 | 22<br>Ti<br>Titanium<br>47.867      | 23<br>V<br>Vanadium<br>50.942   | 24<br>Cr<br>Chromium<br>51.996   | 25<br>Mn<br>Manganese<br>54.938  | 26<br>Fe<br>Iron<br>55.845      | 27<br>Co<br>Cobalt<br>58.933     | 28<br>Ni<br>Nickel<br>58.693       | 29<br>Cu<br>Copper<br>63.546      | 30<br>Zn<br>Zinc<br>65.38         | 31<br>Ga<br>Gallium<br>69.723   | 32<br>Ge<br>Germanium<br>72.631 | 33<br>As<br>Arsenic<br>74.922   | 34<br>Se<br>Selenium<br>78.971    | 35<br>Br<br>Bromine<br>79.904    | 36<br>Kr<br>Krypton<br>83.798   |                                     |
| 37<br>Rb<br>Rubidium<br>85.468  | 38<br>Sr<br>Strontium<br>87.62  | 39<br>Y<br>Yttrium<br>88.906   | 40<br>Zr<br>Zirconium<br>91.224     | 41<br>Nb<br>Niobium<br>92.906   | 42<br>Mo<br>Molybdenum<br>95.95  | 43<br>Tc<br>Technetium<br>98.907 | 44<br>Ru<br>Ruthenium<br>101.07 | 45<br>Rh<br>Rhodium<br>102.906   | 46<br>Pd<br>Palladium<br>106.42    | 47<br>Ag<br>Silver<br>107.868     | 48<br>Cd<br>Cadmium<br>112.414    | 49<br>In<br>Indium<br>114.818   | 50<br>Sn<br>Tin<br>118.711      | 51<br>Sb<br>Antimony<br>121.760 | 52<br>Te<br>Tellurium<br>127.6    | 53<br>I<br>Iodine<br>126.904     | 54<br>Xe<br>Xenon<br>131.293    |                                     |
| 55<br>Cs<br>Cesium<br>132.905   | 56<br>Ba<br>Barium<br>137.328   | 57-71<br>Lanthanide Series     | 72<br>Hf<br>Hafnium<br>178.49       | 73<br>Ta<br>Tantalum<br>180.948 | 74<br>W<br>Tungsten<br>183.84    | 75<br>Re<br>Rhenium<br>186.207   | 76<br>Os<br>Osmium<br>190.23    | 77<br>Ir<br>Iridium<br>192.217   | 78<br>Pt<br>Platinum<br>195.085    | 79<br>Au<br>Gold<br>196.967       | 80<br>Hg<br>Mercury<br>200.592    | 81<br>Tl<br>Thallium<br>204.383 | 82<br>Pb<br>Lead<br>207.2       | 83<br>Bi<br>Bismuth<br>208.980  | 84<br>Po<br>Polonium<br>[209]     | 85<br>At<br>Astatine<br>209.987  | 86<br>Rn<br>Radon<br>222.018    |                                     |
| 87<br>Fr<br>Francium<br>223.020 | 88<br>Ra<br>Radium<br>226.025   | 89-103<br>Actinide Series      | 104<br>Rf<br>Rutherfordium<br>[261] | 105<br>Db<br>Dubnium<br>[262]   | 106<br>Sg<br>Seaborgium<br>[266] | 107<br>Bh<br>Bohrium<br>[264]    | 108<br>Hs<br>Hassium<br>[269]   | 109<br>Mt<br>Meitnerium<br>[278] | 110<br>Ds<br>Darmstadtium<br>[281] | 111<br>Rg<br>Roentgenium<br>[280] | 112<br>Cn<br>Copernicium<br>[285] | 113<br>Nh<br>Nihonium<br>[286]  | 114<br>Fl<br>Flerovium<br>[289] | 115<br>Mc<br>Moscovium<br>[289] | 116<br>Lv<br>Livermorium<br>[293] | 117<br>Ts<br>Tennessine<br>[294] | 118<br>Og<br>Oganesson<br>[294] |                                     |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 71<br>Lu<br>Lutetium<br>174.967     |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 70<br>Yb<br>Ytterbium<br>173.055    |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 103<br>Lr<br>Lawrencium<br>[262]    |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 102<br>No<br>Nobelium<br>259.101    |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 101<br>Md<br>Mendelevium<br>258.1   |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 100<br>Fm<br>Fermium<br>257.095     |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 99<br>Es<br>Einsteinium<br>[254]    |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 98<br>Cf<br>Californium<br>251.080  |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 97<br>Bk<br>Berkelium<br>247.070    |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 96<br>Cm<br>Curium<br>247.070       |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 95<br>Am<br>Americium<br>243.061    |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 94<br>Pu<br>Plutonium<br>244.064    |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 93<br>Np<br>Neptunium<br>237.048    |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 92<br>U<br>Uranium<br>238.029       |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 91<br>Pa<br>Protactinium<br>231.036 |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 90<br>Th<br>Thorium<br>232.038      |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 89<br>Ac<br>Actinium<br>227.028     |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 57<br>La<br>Lanthanum<br>138.905    |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 58<br>Ce<br>Cerium<br>140.116       |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 59<br>Pr<br>Praseodymium<br>140.908 |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 60<br>Nd<br>Neodymium<br>144.243    |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 61<br>Pm<br>Promethium<br>144.913   |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 62<br>Sm<br>Samarium<br>150.36      |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 63<br>Eu<br>Europium<br>151.964     |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 64<br>Gd<br>Gadolinium<br>157.25    |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 65<br>Tb<br>Terbium<br>158.925      |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 66<br>Dy<br>Dysprosium<br>162.500   |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 67<br>Ho<br>Holmium<br>164.930      |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 68<br>Er<br>Erbium<br>167.259       |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 69<br>Tm<br>Thulium<br>168.934      |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 70<br>Yb<br>Ytterbium<br>173.055    |
|                                 |                                 |                                |                                     |                                 |                                  |                                  |                                 |                                  |                                    |                                   |                                   |                                 |                                 |                                 |                                   |                                  |                                 | 71<br>Lu<br>Lutetium<br>174.967     |