

UNIVERSITY OF ESWATINI



MAIN EXAMINATION 2020/2021

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TITLE OF PAPER: INTRODUCTORY CHEMISTRY I

COURSE NUMBER: CHE151

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS: THERE ARE TWO (2) SECTIONS: SECTION A AND SECTION B. ANSWER ALL THE QUESTIONS IN SECTION A AND ANY TWO (2) QUESTIONS FROM SECTION B.

SECTION A IS WORTH 50 MARKS AND EACH QUESTION IN SECTION B IS WORTH 25 MARKS.

THE ANSWER SHEET FOR SECTION A IS ATTACHED TO THE QUESTION PAPER. GIVE YOUR ANSWERS TO THE QUESTIONS IN THIS SECTION BY MAKING A CROSS IN THE GRID PROVIDED, SEE EXAMPLES BELOW. THERE CAN ONLY BE ONE CORRECT ANSWER.

Question	A	B	C	D	E
1			X		
2	X				

AT THE END OF THE EXAM, BEFORE YOU LEAVE, PLACE THE ANSWER SHEET FOR SECTION A INSIDE THE UNESWA ANSWER BOOKLET CONTAINING YOUR ANSWERS TO SECTION B

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A PERIODIC TABLE AND OTHER USEFUL DATA HAVE BEEN PROVIDED WITH THIS EXAMINATION PAPER.

PLEASE DO NOT OPEN THIS EXAMINATION PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE CHIEF INVIGILATOR.

## SECTION A

### MULTIPLE CHOICE [50 MARKS]

Indicate the best option for each of the following multiple choice questions:

1. One angstrom, symbolized Å, is  $10^{-10}$  m.  $1 \text{ cm}^3 = \frac{\quad}{\quad} \text{Å}^3$   
(A)  $10^{24}$  (B)  $10^{-24}$  (C)  $10^{30}$   
(D)  $10^{-30}$  (E)  $10^{-9}$
2. A common English set of units for expressing velocity is miles/hour. The SI unit for velocity is \_\_\_\_\_.  
(A) km/hr (B) km/s (C) m/hr  
(D) m/s (E) cm/s
3. What is the symbol of the element lead?  
(A) Ld (B) Pb (C) Sn  
(D) Hg (E) Le
4. A combination of sand, salt and water is an example of a \_\_\_\_\_.  
(A) homogeneous mixture (B) compound (C) solid  
(D) pure substance (E) heterogeneous mixture
5. Which one of the following has the element name and symbol correctly matched?  
(A) P, potassium (B) C, copper (C) Mg, manganese  
(D) Ag, silver (E) Sn, silicon
6. The \_\_\_\_\_ quantum number defines the shape of an orbital.  
(A) spin (B) magnetic (C) principal  
(D) angular momentum (E) psi
7. Of the following, only \_\_\_\_\_ is a chemical reaction.  
(A) melting of lead (B) dissolving sugar in water  
(C) tarnishing of silver (D) crushing of stones  
(E) dropping 10 cents into a glass of water
8. Which of the following has the same number of significant figures as the number 1.00310?  
(A)  $1 \times 10^6$  (B) 199.791 (C) 8.66  
(D) 5.119 (E) 100
9. Which atom has the largest number of neutrons?  
(A) phosphorus-30 (B) chlorine-37 (C) potassium-39  
(D) argon-40 (E) calcium-40

10. An atom of the most common isotope of gold,  $^{197}\text{Au}$ , has \_\_\_\_\_ protons, \_\_\_\_\_ neutrons, and \_\_\_\_\_ electrons.  
 (A) 197, 79, 118 (B) 118, 79, 39 (C) 79, 197, 197  
 (D) 79, 118, 118 (E) 79, 118, 79

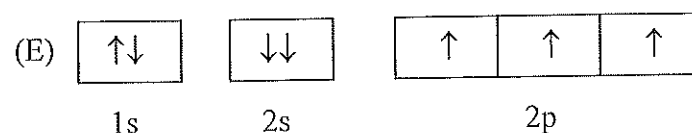
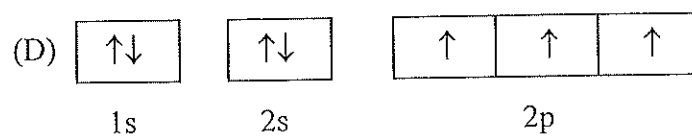
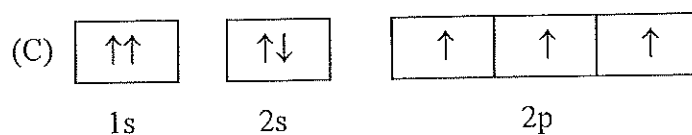
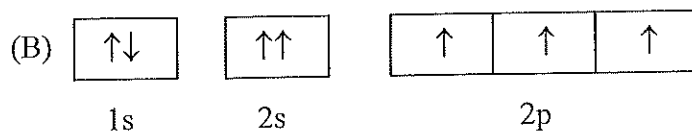
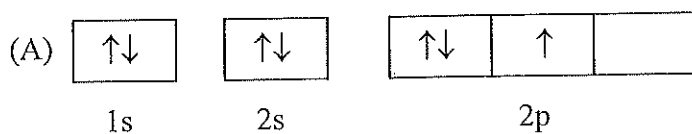
11. The element X has three naturally occurring isotopes. The masses (g/mol) and % abundances of the isotopes are given in the table below. The average atomic mass of the element is \_\_\_\_\_ g/mol.

Isotope	Abundance (%)	Mass (g/mol)
$^{15}\text{X}$	28.60	15.33
$^{17}\text{X}$	13.30	17.26
$^{18}\text{X}$	58.10	18.11

- (A) 17.20 (B) 16.90 (C) 17.65  
 (D) 17.11 (E) 15.90
12. Which one of the following is a non-metal?  
 (A) W (B) Sr (C) Br  
 (D) Os (E) Ir
13. An element that appears in the lower left corner of the periodic table is \_\_\_\_\_.  
 (A) either a metal or metalloid (B) definitely a metal  
 (C) either a metalloid or a non-metal (D) definitely a non-metal  
 (E) definitely a metalloid
14. Which compounds do not have the same empirical formula?  
 (A)  $\text{C}_2\text{H}_2$ ,  $\text{C}_6\text{H}_6$  (B)  $\text{CO}$ ,  $\text{CO}_2$  (C)  $\text{C}_2\text{H}_4$ ,  $\text{C}_3\text{H}_6$   
 (D)  $\text{C}_2\text{H}_4\text{O}_2$ ,  $\text{C}_6\text{H}_{12}\text{O}_6$  (E)  $\text{C}_2\text{H}_5\text{COOCH}_3$ ,  $\text{CH}_3\text{CHO}$
15. Which species has 16 protons?  
 (A)  $^{31}\text{P}$  (B)  $^{34}\text{S}^{2-}$  (C)  $^{36}\text{Cl}$   
 (D)  $^{80}\text{Br}^-$  (E)  $^{16}\text{O}$
16. Which of the following compounds would you expect to be ionic?  
 (A)  $\text{H}_2\text{O}$  (B)  $\text{CO}_2$  (C)  $\text{SrCl}_2$   
 (D)  $\text{SO}_2$  (E)  $\text{H}_2\text{S}$
17. Which species below is the sulphite ion?  
 (A)  $\text{SO}_2^{2-}$  (B)  $\text{SO}_3^{2-}$  (C)  $\text{S}^{2-}$   
 (D)  $\text{SO}_4^{2-}$  (E)  $\text{HS}^-$
18. What is the Kelvin temperature that corresponds to 63 °F.  
**Useful Equations:**  $^{\circ}\text{F} = \frac{9}{5} ^{\circ}\text{C} + 32$ ;  $^{\circ}\text{C} = \frac{5}{9} (^{\circ}\text{F} - 32)$ ;  $\text{K} = ^{\circ}\text{C} + 273$   
 (A) 17 (B) 276 (C) 290 (D) 29 (E) 336

19. A certain liquid has a density of  $2.67 \text{ g/cm}^3$ . What would be the mass in Kg of 30.5 mL of this liquid?  
 (A) 81.4 (B) 11.4 (C) 0.0875  
 (D) 0.0814 (E) 0.0114
20. Which formula/name pair is **incorrect**?  
 (A)  $\text{Mn}(\text{NO}_2)_2$ /manganese(II) nitrite (B)  $\text{Mg}(\text{NO}_3)_2$ /magnesium nitrate  
 (C)  $\text{Mg}(\text{NO}_3)_2$ /magnesium(IV) nitrate (D)  $\text{Mg}_3\text{N}_2$ /magnesium nitride  
 (E)  $\text{Mg}(\text{MnO}_4)_2$ /magnesium permanganate
21. When the following equation is balanced, the coefficient of Al is \_\_\_\_\_.  
 $\text{Al} + \text{H}_2\text{O} \rightarrow \text{Al}(\text{OH})_3 + \text{H}_2$   
 (A) 1 (B) 2 (C) 3  
 (D) 5 (E) 4
22. There are \_\_\_\_\_ sulphur atoms in 25 molecules of  $\text{C}_4\text{H}_4\text{S}_2$ .  
 (A)  $1.5 \times 10^{25}$  (B)  $4.8 \times 10^{25}$  (C)  $3.0 \times 10^{25}$   
 (D) 50 (E)  $6.02 \times 10^{23}$
23. The formula weight of potassium dichromate,  $\text{K}_2\text{Cr}_2\text{O}_7$ , is \_\_\_\_\_ g/mol.  
 (A) 107.09 (B) 255.08 (C) 242.18  
 (D) 294.18 (E) 333.08
24. The mass % of F in the binary compound  $\text{KrF}_2$  is \_\_\_\_\_.  
 (A) 18.48 (B) 45.38 (C) 68.80  
 (D) 81.52 (E) 31.20
25. How many grams of sodium carbonate,  $\text{Na}_2\text{CO}_3$ , contain  $1.773 \times 10^{17}$  carbon atoms?  
 (A)  $3.121 \times 10^{-5}$  (B)  $1.011 \times 10^{-5}$  (C)  $1.517 \times 10^{-5}$   
 (D)  $9.100 \times 10^{-5}$  (E)  $6.066 \times 10^{-5}$
26. A sample of  $\text{CH}_2\text{F}_2$  with a mass of 19 g contains \_\_\_\_\_ atoms of F.  
 (A)  $2.2 \times 10^{23}$  (B) 38 (C)  $3.3 \times 10^{24}$   
 (D)  $4.4 \times 10^{23}$  (E) 9.5
27. The concentration (M) of an aqueous methanol produced when 0.200 L of a 2.00 M solution was diluted to 0.800 L is \_\_\_\_\_ M.  
 (A) 0.800 (B) 0.200 (C) 0.500  
 (D) 0.400 (E) 8.000
28. All of the orbitals in a given subshell have the same value of the \_\_\_\_\_ quantum number.  
 (A) principal (B) azimuthal (C) magnetic  
 (D) A and B (E) B and C

29. Which of the subshells below do **not** exist due to the constraints upon the azimuthal quantum number?  
 (A) 2d (B) 2s (C) 2p  
 (D) all of the above (E) none of the above
30. An electron **cannot** have the quantum numbers  $n = \underline{\quad}$ ,  $l = \underline{\quad}$ ,  $m_l = \underline{\quad}$ .  
 (A) 6, 1, 0 (B) 3, 2, 3 (C) 3, 2, -2  
 (D) 1, 0, 0 (E) 3, 2, 1
31. The            orbital is degenerate with  $5p_y$  in a many-electron atom.  
 (A) 5s (B)  $5p_x$  (C)  $4p_y$   
 (D)  $5d_{xy}$  (E)  $5d^2$
32. How many unpaired electrons are there in a ground state nitrogen atom?  
 (A) 0 (B) 1 (C) 2  
 (D) 3 (E) 4
33. Which one of the following is the correct electron configuration for a ground-state nitrogen (N) atom?



34. The ground state electron configuration of Fe is \_\_\_\_\_.  
 (A)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$  (B)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$  (C)  $1s^2 2s^2 3s^2 3p^{10}$   
 (D)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$  (E)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4d^6$
35. What is the electron configuration for the  $V^{3+}$  ion?  
 (A)  $[Ar]3d^4$  (B)  $[Ar]4s^2 3d^2$  (C)  $[Ar]3d^2$   
 (D)  $[Ar]4s^2 3d^8$  (E)  $[Ar]4s^2$
36. Which two elements have the same ground-state electron configuration?  
 (A) Pd and Pt (B) Co and Cd (C) Fe and Cu  
 (D) Cl and Ar  
 (E) No two elements have the same ground-state electron configuration
37. In which set of elements would all members be expected to have very similar chemical properties?  
 (A) O, S, Se (B) N, O, F (C) Na, Mg, K  
 (D) S, Se, Si (E) Ne, Na, Mg
38. Which isoelectronic series is correctly arranged in order of increasing radius?  
 (A)  $K^+ < Ca^{2+} < Ar < Cl^-$  (B)  $Cl^- < Ar < K^+ < Ca^{2+}$   
 (C)  $Ca^{2+} < Ar < K^+ < Cl^-$  (D)  $Ca^{2+} < K^+ < Ar < Cl^-$   
 (E)  $Ca^{2+} < K^+ < Cl^- < Ar$
39. Of the choices below, which gives the order for first ionization energies?  
 (A)  $Cl > S > Al > Ar > Si$  (B)  $Ar > Cl > S > Si > Al$   
 (C)  $Al > Si > S > Cl > Ar$  (D)  $Cl > S > Al > Si > Ar$   
 (E)  $S > Si > Cl > Al > Ar$
40. Based on the octet rule, magnesium most likely forms a \_\_\_\_\_ ion.  
 (A)  $Mg^{2+}$  (B)  $Mg^{2-}$  (C)  $Mg^{6-}$   
 (D)  $Mg^{6+}$  (E)  $Mg^-$
41. Which of the following would have to lose **two electrons** in order to achieve a noble gas configuration?  
 O Sr Na Se Br  
 (A) O, Se (B) Na (C) Sr, O, Se  
 (D) Br (E) Sr
42. Of the following elements, which one has the most negative electron affinity?  
 (A) S (B) Cl (C) Se  
 (D) Br (E) I
43. A solution of iron(III) chlorate contains the ions  
 (A)  $Fe^{3+}$  and  $ClO_4^-$  (B)  $Fe^{3+}$  and  $ClO^-$  (C)  $Fe^{3+}$  and  $ClO_3^-$   
 (D)  $Fe^{3+}$  and  $ClO_2^-$  (E)  $Fe^{2+}$  and  $ClO_4^-$

44. Which of the following is the phosphide ion?  
(A)  $\text{PO}_3^{3-}$  (B)  $\text{PO}_4^{3-}$  (C)  $\text{P}^{3-}$   
(D)  $\text{P}^{2-}$  (E)  $\text{P}^-$
45. Of the following, only \_\_\_\_\_ is **not** a metalloid.  
(A) B (B) Al (C) Si  
(D) Ge (E) As
46. What is the charge on the iron ion in the salt  $\text{Fe}_2\text{O}_3$ ?  
(A) +1 (B) +2 (C) +3  
(D) -5 (E) -6
47. What is the coefficient of  $\text{O}_2$  when the following equation is balanced?  
$$\text{C}_2\text{H}_4 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$$
  
(A) 2 (B) 3 (C) 4  
(D) 5 (E) 1
48. Automotive air bags inflate when sodium azide ( $\text{NaN}_3$ ) decomposes explosively to its constituent elements:  
$$2\text{NaN}_3(\text{s}) \rightarrow 2\text{Na}(\text{s}) + 3\text{N}_2(\text{g})$$
  
How many moles of  $\text{N}_2$  are produced by the decomposition of 2.88 mol of sodium azide ( $\text{NaN}_3$ )?  
(A) 1.92 (B) 8.64 (C) 4.32  
(D) 0.960 (E) 1.44
49. A 25.5 mL aliquot of HCl of unknown concentration was titrated with 0.113 M NaOH. It took 51.2 mL of the base to reach the endpoint of the titration. The concentration (M) of the acid was \_\_\_\_\_.  
(A) 1.02 (B) 0.114 (C) 0.454  
(D) 0.113 (E) 0.227
50. What volume (L) of 0.250 M  $\text{HNO}_3$  is required to neutralize a solution prepared by dissolving 17.5 g NaOH in 350 mL of water?  
(A) 1.75 (B) 0.44 (C) 50.0  
(D) 0.070 (E)  $1.75 \times 10^{-3}$

## SECTION B

### ANSWER ANY TWO OF THE THREE QUESTIONS [50 MARKS]

#### QUESTION ONE [25 Marks]

- (a) In a titration, 3.25 g sample of an acid, HX, requires 68.8 mL of a 0.750 M NaOH(aq) solution for complete reaction. What is the molar mass of the acid? [5]
- (b) (i) How many possible values for  $l$  and  $m_l$  are there when  $n = 3$ ? [2]  
(ii) Give the values for  $n$ ,  $l$ , and  $m_l$  for  
(1) each orbital in the  $2p$  subshell. [1½]  
(2) each orbital in the  $5d$  subshell. [1½]
- (c) Which of the following are permissible sets of quantum numbers for an electron in a hydrogen atom? For those combinations that are permissible, write the appropriate designation for the subshell to which the orbital belongs (e.g.  $1s$ , and so on). For those that are not permissible briefly explain why they are not permissible.  
(i)  $n = 2, l = 1, m_l = 1$ ; [2]  
(ii)  $n = 1, l = 0, m_l = -1$ ; [2]  
(iii)  $n = 3, l = 3, m_l = 0$ ? [2]
- (d) Write the condensed electron configurations for the following atoms, using the appropriate noble-gas core abbreviations and indicate how many unpaired electrons each has:  
(i) S [2]  
(ii) Ga [2]
- (e) (i) Obtain the fractional abundances for the two naturally occurring isotopes of europium. The masses of the isotopes are  $^{151}\text{Eu}$ , 150.9196 g/mol;  $^{153}\text{Eu}$ , 152.9209 g/mol. The atomic weight is 151.9641 g/mol. [3]  
(ii) You have a stock solution of 14.8 M  $\text{NH}_3$ . How many millilitres of this solution should you dilute to make 100.0 mL of 0.250 M  $\text{NH}_3$ . [2]



## QUESTION TWO [25 Marks]

- (a) (i) The oxygen molecule consists of two oxygen atoms a distance of 121 pm apart. How many millimeters is this distance? [1]
- (ii) Give the normal state (solid, liquid, or gas) of each of the following: [1]
- (1) carbon monoxide [1]
- (2) lead [1]
- (b) (i) Write the formula of magnesium carbonate. [1]
- (ii) Give a systematic name to the binary compound AsH<sub>3</sub>. [1]
- (iii) A fluoride of xenon is prepared by reacting 0.2045 g of Xe with excess F<sub>2</sub> to form 0.3229 g of product. Determine the molecular formula of the product. [5]
- (c) (i) A colourless liquid, used as a solvent is believed to be one of the following:
- | Substance         | Density (in g/mL) |
|-------------------|-------------------|
| n-butyl alcohol   | 0.810             |
| ethylene glycol   | 1.114             |
| isopropyl alcohol | 0.785             |
| toluene           | 0.866             |
- To identify the substance, a chemist determined its density. By pouring a sample of the liquid into a graduated cylinder, she found that the volume was 35.1 mL. She also found that the sample weighed 30.5 g.
- (1) What was the density of the liquid? [1]
- (2) What was the substance? [1]
- (ii) A temperature reading of 77 °F is measured with a Fahrenheit thermometer. What reading would this temperature give if a kelvin thermometer were used? [2]
- (d) (i) For each of the following, write the measurement in terms of an appropriate prefix and base unit. For example,  $1.6 \times 10^{-6} \text{ m} = 1.6 \mu\text{m}$ .
- (1) The radius of an oxygen atom is about 0.000000000066 m. [1]
- (2) The wavelength of a certain ultraviolet radiation is 0.000000056 m. [1]
- (ii) A nucleus consists of 17 protons and 18 neutrons. What is its nuclide symbol? [1]
- (e) Several brands of antacids use Al(OH)<sub>3</sub> to react with stomach acid, which contains primarily HCl:
- $$\text{Al(OH)}_3(\text{s}) + \text{HCl}(\text{aq}) \rightarrow \text{AlCl}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$$
- (i) Balance this equation. [1]
- (ii) Calculate the number of grams of HCl that can react with 0.500 g of Al(OH)<sub>3</sub>. [2]
- (iii) Calculate the number of grams of AlCl<sub>3</sub> and the number of grams of H<sub>2</sub>O formed when 0.500 g of Al(OH)<sub>3</sub> reacts. [4]
- (iv) Show that your calculations in parts (ii) and (iii) are consistent with the **law of conservation of mass**. [1]

### QUESTION THREE [25 Marks]

- (a) You have the mythical metal element "X" that can exist as  $X^+$ ,  $X^{2+}$ , and  $X^{5+}$  ions. What would be the chemical formulae for compounds formed from the combination of each of the X ions and  $SO_4^{2-}$ ? [3]
- (b) (i) Phosphorus oxychloride is the starting compound for preparing substances used as flame retardants for plastics. An 8.53 mg sample of phosphorus oxychloride contains 1.72 mg of phosphorus. What is the mass percentage of phosphorus in the compound? [1]
- (ii) Which contains more carbon, 6.01 g of glucose,  $C_6H_{12}O_6$ , or 5.85 g of ethanol,  $C_2H_6O$ ? [2]
- (iii) A sample of  $NaNO_3$  weighing 0.38 g is placed in a 50.0 mL volumetric flask. The flask is then filled with water to the mark on the neck, dissolving the solid. What is the molarity of the resulting solution? [2]
- (c) A 1.000 L sample of polluted water was analysed for lead(II) ion,  $Pb^{2+}$ , by adding an excess of sodium sulphate to it. The mass of lead(II) sulphate that precipitated was 229.8 mg. What is the mass of lead in a liter of the water? Give the answer as milligrams of lead per liter of solution. [3]
- (d) (i) Which of the following orbital diagrams or electron configuration are possible and which are impossible according to the Pauli exclusion principle? Explain.
- (1)  $\frac{\uparrow\downarrow}{1s} \quad \frac{\uparrow\downarrow\uparrow}{2s} \quad \frac{\quad}{2p} \quad \frac{\quad}{2p} \quad \frac{\quad}{2p}$  [2]
- (2)  $\frac{\uparrow\downarrow}{1s} \quad \frac{\uparrow}{2s} \quad \frac{\uparrow\uparrow}{2p} \quad \frac{\quad}{2p} \quad \frac{\quad}{2p}$  [2]
- (3)  $1s^2 2s^1 2p^7$  [2]
- (ii) An expected experimental outcome is 37.45 grams. Describe the following data sets as accurate and/or precise by selecting "yes" or "No" in each case.
- | Data (g)                | Accurate? | Precise? |
|-------------------------|-----------|----------|
| (1) 37.15, 37.44, 37.75 |           | [1]      |
| (2) 39.43, 37.45, 38.64 |           | [1]      |
- (e) (i) Write the electron configurations of
- (1)  $Fe^{2+}$  [1]
- (2)  $P^{3-}$  [1]
- (ii) How many significant figures are in the number 0.0034050? [1]
- (iii) Potassium is a soft, silvery-coloured metal that melts at 64 °C. It reacts vigorously with water, with oxygen, and with chlorine.
- (1) Identify all of the physical properties given in this description. [1½]
- (2) Identify all of the chemical properties given. [1½]



## UNIVERSITY OF ESWATINI

<b>CHE151 MAIN EXAMINATION ANSWER SHEET</b>	<b>ACADEMIC YEAR 2020/2021</b>
<b>Course Title: Introductory Chemistry I ANSWER SHEET FOR SECTION A OF EXAM</b>	<b>Stud. ID No.</b>
<b>Programme:</b>	
<b>INSTRUCTION: Place an X over the "box" corresponding to the correct answer</b>	

Q. No.	A	B	C	D	E
1					
2					
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18					
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20					
21					
22					
23					
24					
25					

Q. No.	A	B	C	D	E
26					
27					
28					
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50					

Fundamental Physical Constants (six significant figures)

Avogadro's number	$N_A = 6.02214 \times 10^{23} / \text{mol}$
atomic mass unit	$\text{amu} = 1.66054 \times 10^{-27} \text{ kg}$
charge of the electron (or proton)	$e = 1.60218 \times 10^{-19} \text{ C}$
Faraday constant	$F = 9.64853 \times 10^4 \text{ C/mol}$
mass of the electron	$m_e = 9.10939 \times 10^{-31} \text{ kg}$
mass of the neutron	$m_n = 1.67493 \times 10^{-27} \text{ kg}$
mass of the proton	$m_p = 1.67262 \times 10^{-27} \text{ kg}$
Planck's constant	$h = 6.62607 \times 10^{-34} \text{ J}\cdot\text{s}$
speed of light in a vacuum	$c = 2.99792 \times 10^8 \text{ m/s}$
standard acceleration of gravity	$g = 9.80665 \text{ m/s}^2$
universal gas constant	$R = 8.31447 \text{ J}/(\text{mol}\cdot\text{K})$ $= 8.20578 \times 10^{-2} \text{ (atm}\cdot\text{L)} / (\text{mol}\cdot\text{K})$

Rydberg constant =  $1.097 \times 10^7 \text{ m}^{-1}$

SI Unit Prefixes

p	n	$\mu$	m	c	d	k	M	G
pico-	nano-	micro-	milli-	centi-	deci-	kilo-	mega-	giga-
$10^{-12}$	$10^{-9}$	$10^{-6}$	$10^{-3}$	$10^{-2}$	$10^{-1}$	$10^3$	$10^6$	$10^9$

Conversions and Relationships

**Length**  
SI unit: meter, m

1 km	= 1000 m
	= 0.62 mile (mi)
1 inch (in)	= 2.54 cm
1 m	= 1.094 yards (yd)
1 $\mu\text{m}$	= $10^{-12} \text{ m} = 0.01 \text{ \AA}$

**Volume**  
SI unit: cubic meter,  $\text{m}^3$

1 $\text{dm}^3$	= $10^{-3} \text{ m}^3$
	= 1 liter (L)
	= 1.057 quarts (qt)
1 $\text{cm}^3$	= 1 mL
1 $\text{m}^3$	= 35.3 $\text{ft}^3$

**Pressure**  
SI unit: pascal, Pa

1 Pa	= 1 $\text{N/m}^2$
	= 1 $\text{kg/m}\cdot\text{s}^2$
1 atm	= $1.01325 \times 10^5 \text{ Pa}$
	= 760 torr
1 bar	= $1 \times 10^5 \text{ Pa}$

**Mass**  
SI unit: kilogram, kg

1 kg	= $10^3 \text{ g}$
	= 2.205 lb
1 metric ton (t)	= $10^3 \text{ kg}$

**Energy**  
SI unit: joule, J

1 J	= 1 $\text{kg}\cdot\text{m}^2/\text{s}^2$
	= 1 coulomb-volt (1 C·V)
1 cal	= 4.184 J
1 eV	= $1.602 \times 10^{-19} \text{ J}$

**Math relationships**

	$\pi = 3.1416$
volume of sphere	= $\frac{4}{3}\pi r^3$
volume of cylinder	= $\pi r^2 h$

**Temperature**  
SI unit: kelvin, K

0 K	= $-273.15^\circ\text{C}$
mp of $\text{H}_2\text{O}$	= $0^\circ\text{C}$ (273.15 K)
bp of $\text{H}_2\text{O}$	= $100^\circ\text{C}$ (373.15 K)
T (K)	= $T(^{\circ}\text{C}) + 273.15$
T ( $^{\circ}\text{C}$ )	= $[T(^{\circ}\text{F}) - 32] \frac{5}{9}$
T ( $^{\circ}\text{F}$ )	= $\frac{9}{5}T(^{\circ}\text{C}) + 32$

**Solubility of Ionic Compounds**

Soluble Ionic Compounds		Important Exceptions
Compounds containing	$\text{NO}_3^-$	None
	$\text{CH}_3\text{COO}^-$	None
	$\text{Cl}^-$	Compounds of $\text{Ag}^+$ , $\text{Hg}_2^{2+}$ , and $\text{Pb}^{2+}$
	$\text{Br}^-$	Compounds of $\text{Ag}^+$ , $\text{Hg}_2^{2+}$ , and $\text{Pb}^{2+}$
	$\text{I}^-$	Compounds of $\text{Ag}^+$ , $\text{Hg}_2^{2+}$ , and $\text{Pb}^{2+}$
	$\text{SO}_4^{2-}$	Compounds of $\text{Sr}^{2+}$ , $\text{Ba}^{2+}$ , $\text{Hg}_2^{2+}$ , and $\text{Pb}^{2+}$
Insoluble Ionic Compounds		Important Exceptions
Compounds containing	$\text{S}^{2-}$	Compounds of $\text{NH}_4^+$ , the alkali metal cations, $\text{Ca}^{2+}$ , $\text{Sr}^{2+}$ , and $\text{Ba}^{2+}$
	$\text{CO}_3^{2-}$	Compounds of $\text{NH}_4^+$ and the alkali metal cations
	$\text{PO}_4^{3-}$	Compounds of $\text{NH}_4^+$ and the alkali metal cations
	$\text{OH}^-$	Compounds of $\text{NH}_4^+$ , the alkali metal cations, $\text{Ca}^{2+}$ , $\text{Sr}^{2+}$ , and $\text{Ba}^{2+}$

**Standard Reduction Potentials of Selected Half-Reactions**

Metal	Oxidation Reaction
Lithium	$\text{Li}(s) \longrightarrow \text{Li}^+(aq) + e^-$
Potassium	$\text{K}(s) \longrightarrow \text{K}^+(aq) + e^-$
Barium	$\text{Ba}(s) \longrightarrow \text{Ba}^{2+}(aq) + 2e^-$
Calcium	$\text{Ca}(s) \longrightarrow \text{Ca}^{2+}(aq) + 2e^-$
Sodium	$\text{Na}(s) \longrightarrow \text{Na}^+(aq) + e^-$
Magnesium	$\text{Mg}(s) \longrightarrow \text{Mg}^{2+}(aq) + 2e^-$
Aluminum	$\text{Al}(s) \longrightarrow \text{Al}^{3+}(aq) + 3e^-$
Manganese	$\text{Mn}(s) \longrightarrow \text{Mn}^{2+}(aq) + 2e^-$
Zinc	$\text{Zn}(s) \longrightarrow \text{Zn}^{2+}(aq) + 2e^-$
Chromium	$\text{Cr}(s) \longrightarrow \text{Cr}^{3+}(aq) + 3e^-$
Iron	$\text{Fe}(s) \longrightarrow \text{Fe}^{2+}(aq) + 2e^-$
Cobalt	$\text{Co}(s) \longrightarrow \text{Co}^{2+}(aq) + 2e^-$
Nickel	$\text{Ni}(s) \longrightarrow \text{Ni}^{2+}(aq) + 2e^-$
Tin	$\text{Sn}(s) \longrightarrow \text{Sn}^{2+}(aq) + 2e^-$
Lead	$\text{Pb}(s) \longrightarrow \text{Pb}^{2+}(aq) + 2e^-$
Hydrogen	$\text{H}_2(g) \longrightarrow 2\text{H}^+(aq) + 2e^-$
Copper	$\text{Cu}(s) \longrightarrow \text{Cu}^{2+}(aq) + 2e^-$
Silver	$\text{Ag}(s) \longrightarrow \text{Ag}^+(aq) + e^-$
Mercury	$\text{Hg}(l) \longrightarrow \text{Hg}^{2+}(aq) + 2e^-$
Platinum	$\text{Pt}(s) \longrightarrow \text{Pt}^{2+}(aq) + 2e^-$
Gold	$\text{Au}(s) \longrightarrow \text{Au}^{3+}(aq) + 3e^-$

