STEM
Careers Project

STEM Careers Project is a joint venture of the Higher Education Commission and Pakistan Atomic Energy Commission, for grooming talented students for careers in Science, Technology; Engineering & Mathematics (STEM).

Screening TEST: Chemistry
NSTC-21, June 29, 2024

Maximum Marks: 100 Maximum Time: 3 hours

Check List: Before attempting this question paper please make sure that:

i) Paper contains 8 pages including this page and no page is torn or missing

ii) Part I consists of 20 multiple choice questions, Part II contain 50 multiple choice questions and Part III contains descriptive questions

iii) Answer Sheet for MCQs of Part-I & II, and Part III is to be solved on the question paper to be returned back.

1. Part I has 5 multiple-choice questions (MCQs) from each of the subjects of Biology, Computer, Chemistry, Mathematics and Physics. There is a choice between Biology or Computer only, rest of the three subjects are compulsory for every candidate. For Biology or Computer one must blacken the corresponding circle in the answer sheet.
2. Part I has 20 MCQs and carries 20 marks. The MCQ portion of the relevant subject of Part II carries 50 Marks. Correct answer carries +1 mark; 1/3 mark will be deducted for each incorrect answer.
3. In Part I and Part II, there are four choices (a, b, c, d) corresponding to each multiple-choice question. Blacken one of these choices, which in your opinion is correct. Rough work may be done on the question paper.
4. The descriptive question(s) of Part III should be solved on the question paper to be returned back. This part carries 30 Marks.
5. You are recommended to give frank opinion about the test, including pointing out possible mistakes and legibility problems on the last page of the Answer Booklet. It is meant to motivate you to carefully read the question paper before attempting it. It may be used to discriminate between candidates having similar scores.
6. Recommended time for Part I is about 30 minutes and for Parts II and III is about one hour each. The rest of the time is for carefully reading the paper and commenting on it.
7. No leaf from the question paper or Answer Booklet is to be torn out as all these must be handed over to the examiner, even if no question has been attempted. Anyone found using unfair means would be disqualified.
8. You may use non-programmable calculators.
9. No questions will be entertained and no clarification will be made during the test. In case of doubt, please write down your remarks/comments on the last page of the Answer Booklet.
10. You must attempt all Parts of the paper. To qualify screening test one should pass both Parts I and the portion of Parts II and III that are relevant to the discipline in which you have applied to appear.
11. The term 'estimate' if used in the descriptive portion of Part II means that only an approximate answer is expected from the students. Similarly the term 'sketch' in Part III means drawing a rough graph, which looks like what you might expect from more careful considerations.
12. **Possession of CELL PHONE or any IMAGING DEVICE in the Examination Hall will be treated as an offence under unfair mean rules.**
13. Please put your pen down as soon as you hear the announcement of 'stop writing'.

Students will be short-listed for a one-week Training Camp on the basis of their performance on this Screening Test. Results will be posted on NSTC web page: www.stem.edu.pk. Successful candidates will also be informed about their result in about two months after the exam. Please make sure that we have your correct phone/fax number and e-mail address.

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Name:_____ **Roll No:**_____

ABBREVIATIONS AND SYMBOLS					
ampere	A	Faraday constant	F	molal	m
atmosphere	atm	formula molar mass	M	molar	M
atomic mass unit	u	free energy	G	molar mass	M
atomic molar mass	A	frequency	ν	mole	mol
Avogadro constant	N_A	gas constant	R	Planck's constant	h
Celsius temperature	°C	gram	g	pressure	P
centi– prefix	c	heat capacity	C_p	rate constant	k
coulomb	C	hour	h	retention factor	R_f
electromotive force	E	joule	J	second	s
energy of activation	E_a	kelvin	K	temperature, K	T
enthalpy	H	kilo– prefix	k	time	t
entropy	S	liter	L	volt	V
equilibrium constant	K	milli– prefix	m		

CONSTANTS
$R = 8.314\ \text{J·mol}^{-1}\text{·K}^{-1}$
$R = 0.0821\ \text{L·atm·mol}^{-1}\text{·K}^{-1}$
$1\ F = 96{,}500\ \text{C·mol}^{-1}$
$1\ F = 96{,}500\ \text{J·V}^{-1}\text{·mol}^{-1}$
$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$
$h = 6.626 \times 10^{-34}\ \text{J·s}$
$c = 2.998 \times 10^{8}\ \text{m·s}^{-1}$
0 °C = 273.15 K
1 atm = 760 mmHg

EQUATIONS

$$E = E^\circ - \frac{RT}{nF}\ln Q \qquad \ln K = \left(\frac{-\Delta H}{R}\right)\left(\frac{1}{T}\right) + \text{constant} \qquad \ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

PERIODIC TABLE OF THE ELEMENTS

1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.008	2 2A																2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (???)				

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

Name:_____ **Roll No:**_____

PART-I

[CANDIDATE MUST ATTEMPT THIS PART]

[It contains 20 MCQs, 5 from each biology/computer, chemistry, mathematics and physics, for selection to the next phase]

Choose either Biology or Computer and must blacken the correct option in the answer sheet.

BIOLOGY

1. During cellular respiration breakdown of glucose occurs in
   a) Vacuole b) Golgi complex c) Cytoplasm d) Mitochondria
2. The following rays can cause cancer:
   a) X-rays b) Gamma rays c) Alpha and beta particles d) All of these
3. The hypothesis that stands the test of time are called:
   a) Law b) Null Hypothesis c) Principle d) Theories
4. Electric intensity is a ---------- quantity.
   a) vector b) scalar c) basic d) none of these
5. One coulomb is equal to the charge of----------electrons.
   a) 6.25×10^{19} b) 6.24×10^{18} c) 6.24×10^{17} d) 6.25×10^{18}

OR

COMPUTER

1. Internet uses _____ to communicate between devices and networks.
   a) HTTPS b) email c) internet protocol suite d) website
2. Which of the following creates user groups and assigns privileges to them?
   a) Process management b) I/O management c) File management d) Network management
3. In C++, a pointer is
   a) address of a variable b) constant value c) data type of an address variable d) variable for storing address
4. The programming technique where a function calls itself is known as
   a) recursion b) encapsulation c) inline function d) it is a bug
5. Which of the following loop is always executed at least once:
   a) for b) do while c) while d) counter loop

Name:_____ **Roll No:**_____

CHEMISTRY

6. The phenomenon of emission of light in a chemical reaction is known as
   a) Chemiluminescence b) Photosensitization c) Luminescence d) None of these

7. Name the device used to measure the number of nuclear disintegration per minute
   a) Cyclotron b) Geiger counter c) Cloud chamber d) Mass spectrograph

8. Which of the following bonds must be present in alkynes?
   a) Single bond b) Double bond c) triple bond d) Hydrogen bond

9 When a solution contains equal concentration of hydroxyl and hydrogen ions its pH will be around
   a) 0 b) 14 (c) 7 d) 10

10. Which is the most reactive element in the given list?
   a) Fluorine b) Oxygen c) Nitrogen d) Iodine

MATHEMATICS

11. A quadrilateral with vertices at $(0,-1),(3,1),(3,-1),(0,1)$ is a _____.
   a) kite b) square c) parallelogram d) rectangle

12. The center of the circle, _____.
   a) is a point on the circle b) lies outside of the circle c) lies inside of the circle d) none of these

13. What is the sum of all the divisors of 600?
   a) 2060 b) 1860 c) 2160 d) 1890

14. What is the sum of the first nine prime numbers?
   a) 100 b) 98 c) 80 d) 77

15. The equations 2x+7=3 and bx - 10 = -2 have the same solution. What is the value of b?
   a) -4 b) 6 c) 2 d) 3/2

PHYSICS

16. A ball of mass m falls from rest onto a floor, from a height h. It makes elastic collisions with the floor repeatedly. The force exerted by it on the floor, averaged over a long time, is
   a) mg b) 2 mg c) 3 mg d) proportional to m and h

17. While passing over an obstacle a light ray slightly bends round the corner. The phenomenon is known as__:
   a) Scattering b) Polarisation c) Diffraction d) Refraction

18. What is the orbital velocity of geo stationary satellite?
   a) 4.15 km/s b) 2.78 km/s c) 3.08 km/s d) 6.66 km/s

19. What is the direction of electric and magnetic fields in an electromagnetic wave?
   a) parallel to each other, b) at 90° to each other, c) at 45° to each other, d) at 120° to each other

20. What is the time period of a seconds pendulum?
   a) 0.5 second b) 1.0 seconds c) 1.5 seconds d) 2.0 seconds

Name:_____ **Roll No:**_____

PART II – CHEMISTRY

21	How many orbitals are in an atomic sublevel with $l = 3$?						
(a)	3	(b)	5	(c)	7	(d)	9
22	A ground state gaseous atom of which element has the greatest number of unpaired electrons?						
(a)	As	(b)	Br	(c)	Ge	(d)	Se
23	An atom of which element has the highest second ionization energy?						
(a)	Na	(b)	Mg	(c)	Al	(d)	K
24	For the elements in group 14 (C to Pb), which property increases with increasing atomic number?						
(a)	melting points	(b)	covalent radius	(c)	magnitude of stable oxidation state	(d)	ability to form chains of atoms with themselves
25	When NaF, MgO, KCl and CaS are listed in order of increasing lattice energy, which order is correct?						
(a)	MgO, NaF, KCl, CaS	(b)	CaS, MgO, KCl, NaF	(c)	KCl, CaS, NaF, MgO	(d)	KCl, NaF, CaS, MgO
26	A mineral containing only manganese and oxygen contains 69.6% Mn by mass. What is its empirical formula?						
(a)	MnO	(b)	Mn_2O_3	(c)	Mn_3O_4	(d)	MnO_2
27	Toluene, C_7H_8, is added to gasoline to increase its octane rating. What is the volume ratio of air to toluene vapor to burn completely to form CO_2 and H_2O? (Assume air is 20% O_2 by volume.)						
(a)	9/1	(b)	11/1	(c)	28/1	(d)	45/1
28	Which of the following acids does not commonly form acidic salts?						
(a)	HCl	(b)	H_2SO_4	(c)	H_2CO_3	(d)	H_3PO_4
29	Which of the following reactions can not be used to form salts?						
(a)	The reaction between a non-metal and oxygen	(b)	The reaction between a metal oxide and an acid	(c)	The reaction between an acid and a base	(d)	The reaction between an acid anhydride and metal oxide
30	The number of neutrons present in the nucleus of an atom gives different						
(a)	Isotopes	(b)	Isobars	(c)	Positrons	(d)	None of the above
31	How many ml of 0.75N NaOH will be sufficient to neutralize 75 ml of 0.25 N H_2SO_4?						
(a)	25	(b)	50	(c)	75	(d)	100
32	When the principal quantum number of a shell is three ($n=3$). It possesses						
(a)	Only *s* electrons	(b)	Only *p* electrons	(c)	Only *s*, and *p* electrons	(d)	Only *s*, *p*, and *d* electrons
33	Maximum valency of an element is limited to						
(a)	6	(b)	7	(c)	8	(d)	9
34	What is dry ice?						
(a)	Solid CO_2	(b)	Solid NH_3	(c)	Solid N_2	(d)	None of the above
35	Bleaching powder is obtained by passing chlorine over						
(a)	$CaCO_3$	(b)	$Ca(OH)_2$	(c)	$CaHCO_3$	(d)	$Ca(HCO_3)_2$
36	Since the atomic weight of sulphur is twice that of oxygen, the percentage by weight of sulphur in sulphur trioxide is						
(a)	10	(b)	25	(c)	40	(d)	50
37	Hydrogen bonds are obtained between the hydrogen atom of a molecule and another atom of the same or different molecule having						
(a)	Very low electronegativity	(b)	Low electronegativity	(c)	High electronegativity	(d)	Average electronegativity
38	Ionization potential is influenced by						
(a)	The size of the atom	(b)	The charge on the nucleus	(c)	Electrons present in the inner shells	(d)	All of the above
39	According to Fajan's rule cavalent bonding is favoured by						
(a)	Small positive ions	(b)	Large negative ions	(c)	High charge on either ion	(d)	All of the above

Name:_____ **Roll No:**_____

40	In the reaction, $ZnO + C \rightarrow Zn + CO$, carbon acts as						
(a)	Reducing agent	(b)	Oxidizing agent	(c)	Reducing agent as well as oxidizing agent	(d)	None of the above
41	Oxidation number of oxygen is not taken as 2 in which of the following oxides?						
(a)	Acidic oxides	(b)	Basic oxides	(c)	Peroxides	(d)	Amphoteric oxides
42	If a dilute solution of potassium iodide mixed with a small amount of terpentine is allowed to stand in an open vessel, a small amount of hydrogen peroxide is formed. This is due to the process of						
(a)	Autooxidation	(b)	Induced oxidation	(c)	Both (a) and (b)	(d)	None of the above
43	Liquid helium has low boiling point because of						
(a)	Van der Waals forces	(b)	Covalent character	(c)	Ionic character	(d)	Partially ionic character
44	What is formula of gypsum?						
(a)	$CaSO_4$	(b)	$CaSO_4.H_2O$	(c)	$CaSO_4.2H_2O$	(d)	$CaSO_4.3H_2O$
45	Which of the following is true metal						
(a)	N	(b)	P	(c)	As	(d)	Sb
46	Nitric oxide is						
(a)	Basic towards litmus	(b)	Acidic towards litmus	(c)	Neutral towards litmus	(d)	A sweet smelling compound
47	Ozone is a/an						
(a)	Allotrpic modification of oxygen	(b)	Isomer of oxygen	(c)	Polymer of oxygen	(d)	Isotope of oxygen
48	Elements X and Y can combine to form two different compounds. If 1.60 g of X reacts with exactly1.60 g of Y, the compound produced has the formula XY_2. However, under different conditions, 2.40g of X will react with 1.60 g of Y to form a second compound, whose empirical formula is						
(a)	X_3Y_4	(b)	XY	(c)	XY_3	(d)	X_2Y
49	Benzene (C_6H_6) can react with fluorine according to the unbalanced chemical equation $C_6H_6 + F_2 \longrightarrow C_6F_6 + HF$ If this equation is balanced, the number of moles of F_2 required to react with each mole of C_6H_6 is						
(a)	18	(b)	12	(c)	9	(d)	6
50	Given the balanced equation, $3Cu(s) + 8HNO_3(aq) \longrightarrow 3Cu(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$. Determine the mass of copper that would produce 0.167 mol NO(g) when reacted with excess nitric acid						
(a)	10.6 g	(b)	31.8 g	(c)	190.6 g	(d)	15.9 g
51	A 1.56 g sample of a compound containing only carbon and hydrogen was completely burned. The reaction produced 5.28 g of CO_2 and 1.08 g of H_2O. What is the empirical formula of the compound?						
(a)	CH_2	(b)	C_5H_3	(c)	C_2H_5	(d)	CH
52	Which one of the following has the largest radius?						
(a)	the Na atom	(b)	the Mg atom	(c)	the Ca^{2+} ion	(d)	the K atom
53	In which one of the following lists are all the substances covalently bonded?						
(a)	NO, HBr, LiOH	(b)	CO_2, NH_3, F_2	(c)	CO, $BaCl_2$, N_2	(d)	CH_4, H_2O, Ne
54	By photosynthesis using solar energy, maple trees make molecules of glucose in the reaction, $6CO_2(g) + 6H_2O(l) \longrightarrow C_6H_{12}O_6(s) + 6O_2(g)$ $\Delta H = +2815$ kJ/mol glucose. To make 20 g of glucose, how much solar energy must the maple leaves absorb (if the process is 100% efficient)?						
(a)	239 kJ	(b)	469 kJ	(c)	141 kJ	(d)	313 kJ
55	A student generates 41.0 mL of dihydrogen (H_2) by reacting solid magnesium with hydrochloric acid at 20°C. He then heats the gas produced to 35°C without changing the pressure. What will be the final volume of H_2?						
(a)	43.1 mL	(b)	71.8 mL	(c)	39.0 mL	(d)	23.4 mL
56	At 70°C and atmospheric pressure of 101.3 kPa, a light bulb with a volume of 212 mL contains 0.152 g of a pure gas. What is this gas?						
(a)	Ne	(b)	Ar	(c)	Kr	(d)	N_2
57	An aqueous solution of concentrated hydrobromic acid contains 48% HBr by mass. If the density of the solution is 1.50 g/mL, what is its concentration?						
(a)	11.4 mol/L	(b)	8.9 mol/L	(c)	5.9 mol/L	(d)	18.5 mol/L

Name:_____ **Roll No:**_____

58	In a certain solution the concentration of the OH^- ion is 100 times greater than the concentration of the H^+ ion. What is the pH of this solution?						
(a)	12	(b)	8	(c)	6	(d)	2
59	Formic acid (HCO_2H) is a weak monoprotic acid in aqueous solution. An aqueous solution is made by dissolving 1.00 mol of formic acid in sufficient water to make 1.00 L of solution. Which one of the following species is present in largest concentration?						
(a)	H_3O^+	(b)	OH^-	(c)	HCO_2^-	(d)	HCO_2H
60	What is the oxidation state of manganese in $KMnO_4$?						
(a)	+1	(b)	+5	(c)	+7	(d)	+2
61	The solubility product constant of BiI_3 is 8.2×10^{-19}. The solubility of this salt in pure water is therefore						
(a)	9.1×10^{-10} mol/L	(b)	3.0×10^{-5} mol/L	(c)	2.1×10^{-19} mol/L	(d)	1.3×10^{-5} mol/L
62	An element X forms two oxides whose formulas are XO_3 and X_2O_3. One of these oxides contains 52% of X by mass and has a molar mass of 99.98. What is the formula of this oxide?						
(a)	Mg_2O_3	(b)	K_2O_3	(c)	CrO_3	(d)	Al_2O_3
63	The aqua regia can be prepared with concentrated nitric acid whose concentration is 16 M (16 mol/L). What volume of this acid would be required for complete reaction with 11.6 g of Pt?						
(a)	35.5 mL	(b)	312 mL	(c)	2.79 mL	(d)	4.95 mL
64	Oxygen condenses at –183°C and freezes at –223°C. According to the kinetic molecular theory, the kinetic energy of oxygen molecules is zero at						
(a)	–183°C	(b)	–273°C	(c)	–373°C	(d)	–223°C
65	Nickel tetracarbonyl, $Ni(CO)_4$, is formed by the reaction of nickel metal and carbon monoxide. If 0.118 g of nickel reacts at 21°C with 570 mL of CO at an initial pressure of 2.00 atm, what is the pressure of CO after the reaction?						
(a)	0.34 atm	(b)	0.64 atm	(c)	1.92 atm	(d)	1.66 atm
66	Which substance would you expect to have the highest melting point.						
(a)	GeI_4	(b)	I_2	(c)	KI	(d)	CH_3I
67	An antifreeze mixture consists of 40% ethylene glycol ($C_2H_6O_2$) by weight in aqueous solution. If the density of this solution is 1.05 g/mL, what is the molar concentration?						
(a)	6.77 M	(b)	6.45 M	(c)	0.017 M	(d)	16.9 M
68	The ion $H_2PO_4^-$ can acts as either an acid or a base. Its conjugate base and acid are respectively						
(a)	H_3PO_4 and HPO_4^{2-}	(b)	HPO_4^{2-} and H_3PO_4	(c)	PO_4^{3-} and HPO_4^{2-}	(d)	H_3PO_4 and PO_4^{3-}
69	What is the pH of a solution of 10^{-9} M NaOH?						
(a)	5	(b)	6	(c)	7	(d)	9
70	The solubility of AgBr in pure water is 5.7×10^{-7} M (at 25°C). What is the solubility of AgBr in a solution which contains 0.01 mol of NaBr per litre?						
(a)	3.25×10^{-7} M	(b)	5.7×10^{-5} M	(c)	7.55×10^{-5} M	(d)	3.25×10^{-11} M

Part III: Chemistry-Descriptive Questions
[Max points 30: All questions carry equal points]

Question 1: Why won't iron dissolve as easily in HNO_3 as it does in HCl?

Answer:

Name:_____ **Roll No:**_____

Question 2: What's the difference between baking soda and baking powder?
Answer :

Question 3: How do nonpolar molecules like O_2 dissolve in water?
Answer :

Question 4: What is the difference between valence, and number of valence electrons?
Answer :

----End of paper----