PRACTICE PAPERS CHEMISTRY OLYMPIADS

STAGE – 2

Paper – 06 Part – C

TIME: 1HR 30MIN MAX MARKS: 180

- Attempt all the Questions.
- All questions carry +3 for right answer and -1 for wrong answer.
- Use of Calculator is allowed.

PERIODIC TABLE OF THE ELEMENTS

1 1A																	18 8A
1 H 1.008	2 2A											13 3A	14 4A	15 5A	16 6A	17 7A	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 78.97	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 95.95	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 Ds (281)	111 Rg (272)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (289)	116 Lv (293)	117 Ts (294)	118 Og (294)

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: …….

Correct Questions =…… **Wrong Questions = …..** **Unattempt Questions = ……**

Marks = ……

Lab Problem 1

Turmeric, a natural compound, is added to mustard for flavor and color. It changes color from yellow to red at a pH of 7.4. Mustard also contains acetic acid. Given a sample of 0.50 M NaOH and the packets of mustard, create and perform an experiment to determine the mass percentage of acetic acid in mustard.

Lab Problem 2

Given a sample of 3.0 M hydrochloric acid, phenolphthalein, and some common laboratory equipment, devise an experiment using both *qualitative* and *quantitative* evidence to determine the provided unknown metal given these possible choices: Ag, Al, Ca, or Cr.

approval (for safety reasons) from the examiner.

2. Record your data and other observations.

3. Calculations.

The calculations would be:

1. moles base used (V x M) = moles acid present

2. moles acid present x molar mass acetic acid = mass acetic acid

3. Percentage of acetic acid in mustard = mass acetic acid present / mass mustard used

Sample Calculation:

0.50 g mustard weighed, titrated with a volume of 0.5 mL NaOH

moles OH- = 0.0005 L x 0.5M = 0.00025 mol OH-

= 0.00025 mol H+ from HC2H3O2 in mustard

mass HC2H3O2 = 0.00025 mol x 60 g/mol = 0.015 g HC2H3O2

finally, % acetic acid in mustard = 0.015 g /.50 g x100 = approx. 3.0%

The percentage of acetic acid in your sample of mustard = ___3.0%_____

Excellent work:
Student was able to complete two or more trials and average their results, using a minimum amount of both mustard and NaOH for each titration. Results were clearly shown and observations, i.e. color changes and endpoint were clearly noted.

Student thought to make dilute aqueous solutions with each of the samples of mustard in order to completely dissolve the mustard and be able to more clearly note a uniform and lasting color change

Average work:
Student only completed one trial. Evidence of a titration was performed. Measurements between trials were fairly consistent.

Below average work:
Student was not able to conclude that this was a titration experiment, or did so, but did not perform the titration correctly to obtain a mass/volume of NaOH added. Only one trial was performed. Measurements were inaccurate or inconsistent between trials.

1. Give a brief description of your experimental plan.

Students were to provide both qualitative and quantitative evidence to determine the unknown metal. The metal provided was calcium. The results to this experiment should have included both evidence form data obtained and exclusive information about what was not observed from students' previous chemical knowledge. Conclusions come from knowledge about each metals' reactivity to both water and HCl, with phenolphthalein, a possible titration, and gas generation. Students might also have explored reactivity of the metal with NaOH from Problem #1 (this is allowed, though not necessary to successfully complete this problem).

Excellent work:
Student combined HCl with the unknown metal (Ca) to obtain hydrogen gas in the well-plate, clearly showing evidence of gas production and exothermic reaction. A titration The student then performed this reaction with a measured amount of Ca and excess HCl using the Luer-Lok syringe to quantify the hydrogen gas produced (since room temperature and pressure were not given, student had to make some assumptions about the Kelvin temperature and room pressure, perhaps estimating 298K and 1 atm) to determine the expected volume of hydrogen and compare it to a theoretical volume produced from
$Ca + HCl \quad CaCl_2 + H_2$
Noting the color change when phenolphthalein is added to the metal reacted to either water or HCl. It is possible that a student might have thought to combine mustard (from Prob.#1) with the metal from this experiment. If so, mustard on the surface of Ca produces over time a crusty white solid, $Ca(C_2H_3O_2)_2$ (there is no evidence of reaction with mustard on the surface of Cr and with pure Ag, no visible reaction).

Concluding what DIDN'T occur:
If Cr + HCl greenish color indicating $CrCl_3$ (or green color with many chromium salts
If Ag + HCl no reaction
If Al + HCl no visible reaction due to aluminum oxide layer (though student might have attempted to dissolve the metal with the NaOH from Exp. #1, if Al, would dissolve; Ca + NaOH gives $Ca(OH)_2$, a noticeable milky white precipitate, with phenolphthalein produces a pink color.

a) Sample titration experiment conclusions:

Reacting a 0.10 g metal turning with water completely, adding phenolphthalein, then titrating with the 3M HCl to obtain a 2 : 1 ratio of OH^- : H^+ in solution, confirms that OH^- must be present in the metal hydroxide form, $M(OH)_2$.

b) Sample data for quantifying hydrogen gas generated using the Luer-Lok® syringe:

One metal turning, approx. 0.07 g Ca in excess 3M HCl

Begin at 12 mL mark on syringe
End at 40 mL mark on syringe
40 – 12 = 28 mL hydrogen gas generated, strongly exothermic reaction.

Assume room temp. 25oC (298K) and 1 atm: using the ideal gas law, PV = nRT

(1 atm)(0.028L) = n (0.0821atm L/mol K) (293K) ; n = 0.00116 mol $H_2(g)$

if given 0.07g of calcium, $Ca + 2HCl \rightarrow CaCl_2(aq) + H_2(g)$, then 0.0035 g of hydrogen gas is produced, corresponds roughly to number of moles of $H_2(g)$ made with these assumed conditions.

Average work:

Student reacted metal with HCl and concluded hydrogen gas was present but didn't quantify the gas produced, or did but incorrectly. Student wrote out possible reactions with the other possibilities but did not do so correctly.

Below average work:
Student was unable to conclude that hydrogen gas was produced, did not use either a titration or quantitative method of data collection, or unable to use the phenolphthalein to qualitatively justify the metal.