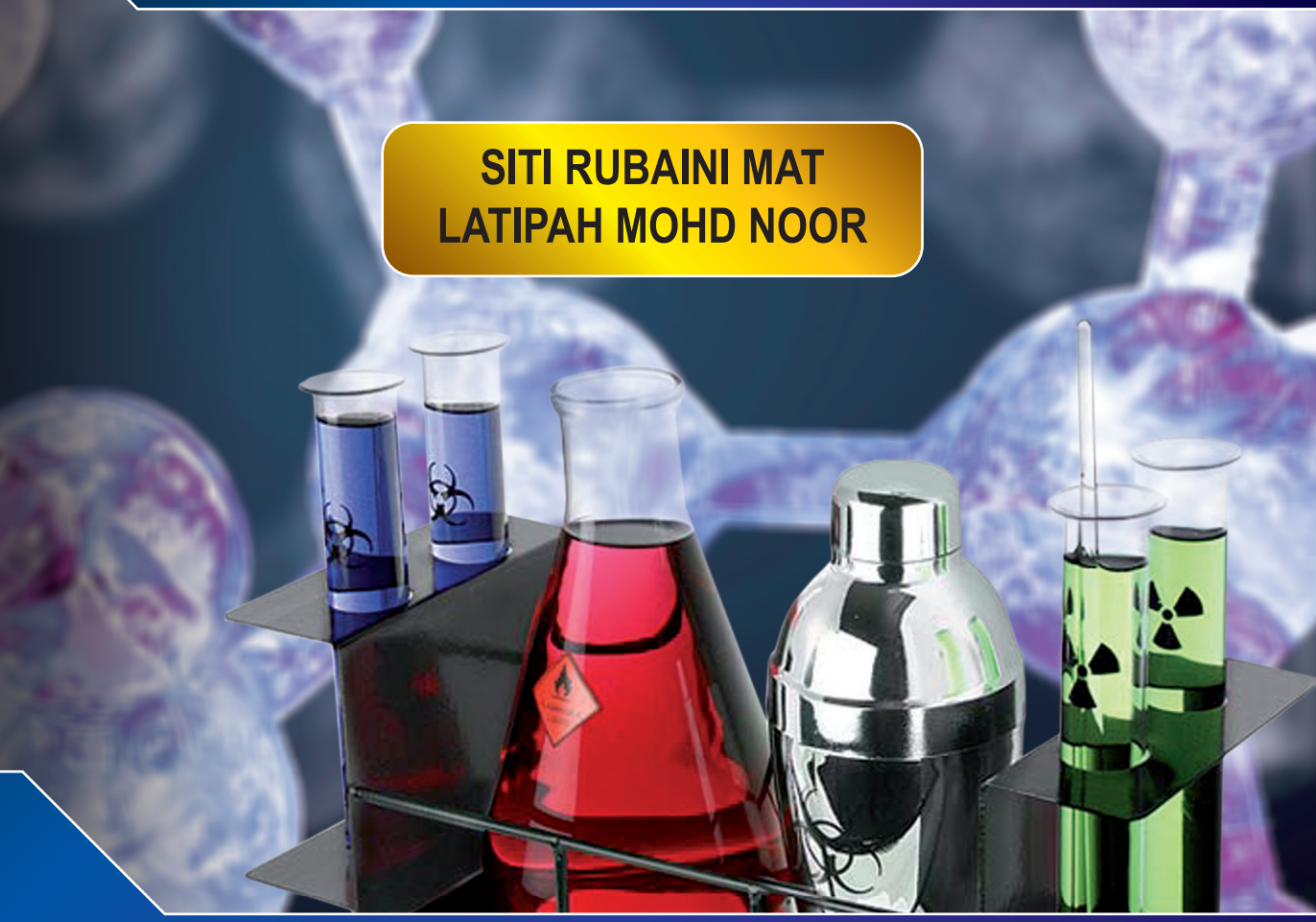
LABORATORY MANUAL

CHEMISTRY II

TMS 0434

SITI RUBAINI MAT
LATIPAH MOHD NOOR



UNIVERSITI SAINS ISLAM MALAYSIA
جَامِعَة العُلوم الإسْلامِيَة المَالِيزِيَة
ISLAMIC SCIENCE UNIVERSITY OF MALAYSIA

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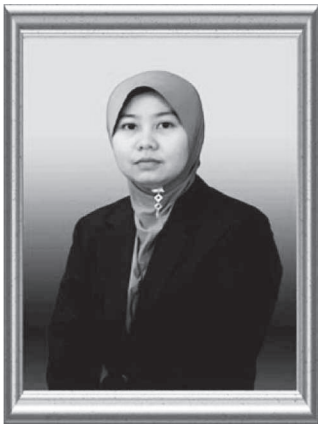

Assalamualaikum warahmatullah,

I would like to express gratitude to those involved in this publication straight from the beginning when a workshop was proposed for the Tamhidi Chemistry Unit. Dedications, cooperation and strong teamwork during those sessions by the lab assistants and teachers were very much appreciated.

This Laboratory Manual is a guideline for students in Semester II to complete their studies of foundation chemistry. Each experiment is carefully chosen and edited for the purpose of maximizing the impact in the learning outcome. Students should be able to incorporate what they have learnt in the lecture hall and tutorials classes with the experiments in this Laboratory Manual. Students should also be curious enough to explore similar experiments which they can find in many websites, some with even related simulations, calculations and discussions.

I believe that this Laboratory Manual will be used to its full potential for the teaching and learning purposes, and these students may still going to refer to this manual when they have moved on to the undergraduate level. It is hoped that Tamhidi Centre will be able to develop students that can integrate the naqli and aqli knowledge along with good character development as a platform to create an excellent generation corresponding with the university's mission.

Berilmu, Beramal, Bertaqwa.

Dr Nurlida Basir
Director of Tamhidi Centre, USIM
25 May 2011

LABORATORY SAFETY RULES AND AGREEMENT

Name : _____

Matrics Number : _____ **Tutorial :** _____

Lecturer's Name: 1) _____

2) _____

Read these General Laboratory Safety Rules carefully.

1. Attendance is **COMPULSORY.** If a student is unable to attend any practical classes, a medical certificate (MC) or a letter of exemption should be produced.

2. **SAFETY IS A PRIORITY.** Remember the location and proper use of all laboratory safety equipment, including eyewash, safety shower, fire alarm, fire extinguisher, and telephone. Notify your lecturer immediately of **ANY** injury, spill, fire, or explosion. **NEVER** leave an ongoing experiment unattended. Always know the hazards and physical and chemical properties of the materials used. Notify your lecturer and follow appropriate procedures if there is a mercury spill due to a broken mercury thermometer. Take every precaution to keep all chemicals from coming into contact with your skin and clothing, and away from flames.

3. When attending practical classes, every student should bring along a small towel, the laboratory manual and wear a **LAB COAT**, proper closed toed shoes (no sandals or slippers) and safety goggles (when needed). Long hair and loose clothing must be confined or tied back. Head scarves should be tucked under your lab coat. High heels, baggy clothing, dangling jewellery, and shoes made of woven materials are strongly discouraged. Do not wear contact lenses for experiments when handling volatile solutions because they may be trapped under the lenses.

4. Every student must check the condition of all the apparatus to be used before starting the experiments. If there is a shortage of apparatus or breakage, please report it to the lecturer or the lab assistant immediately.

5. Be careful not to contaminate the chemicals. To avoid contamination, **NEVER** put your pipette into the reagent bottle and **NEVER** return unused chemicals to their bottle. When pouring out reagents, hold the stopper in your hand. Do not put it on the table. When replacing the stopper, place it first at the opening to ensure that any droplets present do not split outside the reagent bottle. When diluting concentrated acids, always add the acids to water.

6. Take only sufficient amounts of chemicals for your experiments and use them with care. Try to dispense only what will be needed. Share any excess. Do not waste chemicals.

7. Playing, pranks and other acts of mischief are strictly forbidden. You are strictly forbidden to eat or drink in the laboratory at anytime. Do not taste anything. If instructed to smell a chemical, do so by carefully fanning the top of test tube or bottle so that a little of the vapour is directed towards your nose.

8. Never remove chemicals from the labs or stockrooms without proper authorization. Unauthorized experiments, work, and preparations are not allowed. Know and follow the specified procedures for each experiment.

9. Read labels carefully. Label all containers to avoid errors. Make sure that the label is at the top when pouring out liquids from their bottles.

10. Turn off or lower all Bunsen flames when not in use. When heating liquid in a beaker, always place it on wire gauze on a tripod stand. Ensure that the mouth of the test tube is not pointed towards yourself or your friends when heating liquids in a test tube.

11. Handle compounds that emit irritating vapours in the fume cupboard. Ensure there are no flames in the vicinity before working with inflammable compounds. Immediately douse off any flame with fire extinguisher.

12. Keep your work area clean and tidy. All glassware must be washed after use. Return the apparatus and reagent bottles after the experiments. Clean up small spills immediately. Do not throw any solid wastes into the sinks. Dispose of organic solvents in the waste container provided.

13. Wash your hands and arms with soap and water before you leave the lab, even if you have been wearing gloves.

I understand that the laboratory situation is potentially dangerous. Therefore, I have read and understood the lab rules and regulations as stated above. I agree to abide by all these rules, follow the lecturer's instructions and act responsibly at all times.

Signed : _____ Date : _____

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Signed : _____ Date : _____

PREFACE

This Laboratory Manual is created especially for the Tamhidi Programme of Medicine (TM), Dentistry (TD) and Science and Technology (TST), Tamhidi Centre, USIM. The topics are arranged according to the syllabus of chemistry for foundation studies. The main objectives of the laboratory practices is to provide better understanding of the concepts of chemistry discussed in the lectures by carrying out experiments.

During this semester, students will be exposed to the concepts of thermodynamics, reaction rates, electrochemistry and organic chemistry. It is critical for the students to read through the lecture notes on relevant topic prior to the laboratory sessions. Only two hours is given to the students in groups of three to complete each experiment.

It is important for the students to read and sign the Laboratory Safety Rules and Agreement as the first task. Submission of this agreement is crucial as the students should take precautions and be very careful in the laboratory. Before the students start any activity, a briefing will be provided by the instructors and demonstrators.

The schedule of laboratory rotation will be provided in the course outline available online. Students should be able to log in individually using their own accounts in GOALS. The vacant days when the students will not have laboratory sessions will be filled with topical quizzes and revision classes.

During laboratory sessions, students will be evaluated by the instructors and demonstrator with the help of lab assistants on dress code, apparatus handling, experimental procedures, behaviour during sessions, report submitted and team work.

At the end of each session, students would have to submit the laboratory handout on time. Each group is required to submit only one set of handout as the report of the day. The students should also fill in the handout in their respective laboratory manual as at the end of the semester, a laboratory theory exam will be carried out. The report submitted will not be returned back to the students.

Finally, we would like to welcome any comments from any parties especially academicians and chemists to improve this Laboratory Manual.

Chemistry Unit
Tamhidi Centre, USIM
May 2011

ACKNOWLEDGEMENT

We would like to thank the Director of Tamhidi Centre, Dr Nurlida Basir for her encouragement and support starting from the beginning, when this Laboratory Manual is firstly initiated. It was suggested by the laboratory staff for us to publish a manual which reflects the quality of experiments done by the Tamhidi students. A workshop was held on 30 March 2011 and all the experiments were carried out and the procedures were improved.

Material supports and ideas are also contributed by the facilitator of the workshop, Dr Salina Mat Radzi whom at that time was the coordinator of the Science Programme in Tamhidi Centre. Her attention to Chemistry Unit is a motivation for us to keep continuing a good teamwork in the laboratory.

Our team in the workshop were Cik Norhafiza Abdul Ghafar, En Muhammad Fariz Mat Saad, En Mohd Yusuf bin Itam Abdullah dan Pn Norfiza Zakaria. Thank you very much for the cooperation and hard work given not only during the workshop but also throughout the whole laboratory session with the students.

Last but not least, we would like to thank our parents and families for their unlimited support for our work and studies.

Siti Rubaini Mat
Latipah Mohd Noor
6 September 2011

POINTS ALLOCATION AND GRADING SYSTEM

The students should read through the lecture notes on relevant topic prior to the laboratory sessions. This is because only two hours is given for the students in groups of three to complete each experiment. At the end of the session, every group will have to submit the results and discussion as attached in this Laboratory Manual. Students do not have to write a full report on each experiment. Submission of a complete handout from this manual is a must.

At the beginning of the semester, students will be given the grouping name list and also the timetable for the laboratory sessions. The vacant week when the students are not going to have laboratory sessions will be filled with topical quizzes and revision classes.

Table A below represents allocated points for every experiment which will carry 10% of the grading for this subject, TMS 0434 Chemistry II.

Table A: Allocated points for individual experiment.

Title of experiment	Allocated points	Psychomotor points	Total points
Experiment 1: Thermochemistry	15	30	45
Experiment 2: Nerst Equation	15	30	45
Experiment 3: Reaction Rates	30	30	60
Experiment 4: Reactions of Hydrocarbons	25	30	55
Experiment 5A: Classifications of Alcohols Experiment 5B: Aldehyde and Ketone	20	30	50

At the end of each session, students would have to submit the laboratory handout on time. One group will only submit one set of handout as the report of the day. The other two students should also fill in the handout in their respective laboratory manual as at the end of the semester, a laboratory theory exam will be carried out. The report submitted will not be returned back to the students.

Assessment component for this course is as given in Table B. The grading system which has been applied by Tamhidi Centre since Semester 1 Session 2008/2009 is as listed in Table C. Table D in the next page shows the rubric evaluation guidelines for psychomotor elements throughout the whole session.

Table B: Assessment component for the whole course.

Component	No. of papers	Type of question	Marks	Time allocated	Weightage
Continuous assessment	4 6 1 1	Topical Test Lab Evaluation Lab Test Presentation	30 40-60 30 30	1 hour 2 hours 1 hours 15 minutes	10% 5% 5% 5%
Mid-Semester Exam	1	Structured	50	1½ hours	15%
Final Semester Exam	1	Objective Structured Essay	20 40 40	3 hours	60%
Total					100%

Table C: Tamhidi Grade System

Total Marks	Grade	Cumulative Points
80-100	A	4.00
75-79	A-	3.75
70-74	B+	3.50
65-69	B	3.00
60-64	B-	2.75
55-59	C+	2.50
50-54	C	2.00
45-49	C-	1.75
40-44	D+	1.00
0-39	E	0.00

LIST OF APPARATUS AND CHEMICALS

Topic	Apparatus	Quantity	Chemical Reagents	Quantity
Experiment 1 Thermochemistry	coffee cup	1	NaOH 1.0 M	75 mL
	calorimeter with lid		HCl 1.0 M	75 mL
			distilled water	50 mL
	100 mL beaker	1		
	measuring cylinder	1		
	conical flask	1		
	thermometer	1		
	stop watch			
	water bath/hot plate	1		
Experiment 2 Electrochemistry	Voltmeter	1	0.1 M $CuSO_4$	75 mL
	salt bridge	1	0.1 M $ZnSO_4$	75 mL
	sand paper		zinc electrode	
	pipette filler	1	copper electrode	
	crocodile clips	2		
	50 mL beaker	2		
	25 mL pipette	2		
	25 mL volumetric flask	1		
	50 mL volumetric flask	1		
	5 mL graduated pipette	1		
	1 mL graduated pipette	1		
Experiment 3 Reaction rates	boiling tubes	6	0.10 M HCl	50 mL
	steam bath		10% $MnSO_4$	10 drops
	stop-watch	1	0.2 M $KMnO_4$	20 mL
	thermometer	1	2.00 M H_2SO_4	40 mL
	Bunsen burner	1	0.10 M $Na_2S_2O_3$	160 mL
	10 mL pipette	1	0.25 M $H_2C_2O_4$	40 mL
	50 mL burette	1	distilled water	100 mL
	100 / 250 mL conical flask	4		
	glass rod	1		

Topic	Apparatus	Quantity	Chemical Reagents	Quantity
Experiment 4 Hydrocarbons	evaporating dish wooden splinter dropper test tubes tile/ A4 white paper	1 2 2 1	cyclohexane cyclohexene toluene basic $KMnO_4$	2 mL 2 mL 2 mL 2 mL
Experiment 5A Aldehyde and Keton	test tubes with corks water bath dropper 10 mL measuring cylinder	10 2 2	n-butanol 2-butanol t-Methyl-2-propanol / tert-butanol alcohol X concentrated H_2SO_4 1% $Na_2Cr_2O_7$ (aq) anhydride glacial acetic acid Lucas' reagent	2 mL 2 mL 2 mL 2 mL 2 mL 1 mL 1 mL
Experiment 5B Aldehyde and Keton	test tubes thermometer water bath stopper	10 1 2	ethanal benzyldehyde, butanone 1 sample of an unknown compound 2,4-dinitrophenylhydrazine Fehling's solution Schiff's reagent Iodine solution 10% NaOH solution $AgNO_3$ NaOH NH_4OH Dioxane or its equivalent	2 mL 2 mL 2 mL 2 mL 3 mL 8 mL 4 mL 3 mL 2 mL 5 mL 5 drops 2 mL

INTRODUCTION TO LABORATORY RULES AND USAGE OF LABORATORY EQUIPMENT

Objectives

1. To read and understand all chemistry laboratory safety rules and regulations.
2. To know the correct techniques of handling laboratory apparatus.

Introduction

The chemistry laboratory should be a safe place to work in. For this reason, students should know all laboratory rules and regulations, including the correct way of using lab apparatus and handling of chemicals.

Laboratory Rules and Regulations

1 Attendance

Attendance is **COMPULSORY**. All students undergoing the **TAMHIDI OF MEDICINE, TAMHIDI OF DENTISTRY** and **TAMHIDI OF SCIENCE AND TECHNOLOGY** programmes in **UNIVERSITI SAINS ISLAM MALAYSIA, USIM** are required to attend practical classes of two hours each. Students are required to complete at least five experiments each semester. If a student is unable to attend any practical classes, he / she should produce *a medical certificate (MC)* or *a letter of exemption.*

Every student should:
(i) Bring along a small towel,
(ii) Have a Laboratory Manual and laboratory handouts ready, and
(iii) Wear a lab coat, proper closed toed shoes (no sandals or slippers) and safety goggles (when needed).

2 Apparatus

SAFETY IN THE LAB IS FIRST PRIORITY. Every student must check the condition of all the apparatus to be used before starting the experiments. If there is a shortage of apparatus or breakage, please report it to the lecturer or the lab assistant immediately.

Every student is required to use and handle all apparatus with care. All apparatus and the work area must be cleaned after completing experiments. Check all glassware for cracks before using it. Cracks could cause the glassware to fail

APPENDIX B

TABLE OF RELATIVE ATOMIC MASSES

Element	Symbol	Proton number	Relative Atomic Masses
Aluminium	Al	13	27.0
Silver	Ag	47	107.9
Argon	Ar	18	40.0
Arsenic	As	33	74.9
Gold	Au	79	197.0
Barium	Ba	56	137.3
Beryllium	Be	4	9.0
Bismuth	Bi	83	209.0
Boron	B	5	10.8
Bromine	Br	35	79.9
Iron	Fe	26	55.9
Flourine	F	9	19.0
Phosphorus	P	15	31.0
Helium	He	2	4.0
Mercury	Hg	80	200.6
Hydrogen	H	1	1.0
Iodine	I	53	126.9
Cadmium	Cd	48	112.4
Potassium	K	19	39.1
Calcium	Ca	20	40.1
Carbon	C	6	12.0
Chlorine	Cl	17	35.5
Cobalt	Co	27	58.9
Krypton	Kr	36	83.8
Chromium	Cr	24	52.0
Copper	Cu	29	63.6
Lithium	Li	3	6.9
Magnesium	Mg	12	24.3

Manganese	Mn	25	54.9
Sodium	Na	11	23.0
Neon	Ne	10	20.2
Nickel	Ni	28	58.7
Nitrogen	N	7	14.0
Oxygen	O	8	16.0
Platinum	Pt	78	195.1
Lead	Pb	82	207.2
Protactinium	Pa	91	231.0
Radium	Ra	88	226.0
Radon	Rn	86	222.0
Rubidium	Rb	37	85.5
Selenium	Se	34	79.0
Cerium	Ce	58	140.1
Caesium	Cs	55	132.9
Silicon	Si	14	28.1
Scandium	Sc	21	45.0
Tin	Sn	50	118.7
Antimony	Sb	51	121.8
Strontium	Sr	38	87.6
Sulphur	S	16	32.1
Uranium	U	92	238.0
Tungsten	W	74	183.9
Zinc	Zn	30	65.4

APPENDIX C

Table of Standard Reduction Potentials

Cathode (Reduction)	Half Reaction Standard Potential E^o (V)
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$Ag^{2+}(aq) + e^- \rightarrow Ag^+(aq)$	+1.98
$Ag_2O(s) + 2H^+ + 2e^- \rightarrow 2Ag(s)$	+1.17
$Ag_2O_3(s) + 6H^+ + 4e^- \rightarrow 2Ag^+(aq) + 3H_2O(l)$	+1.67
$AgO(s) + 2H^+ + e^- \rightarrow Ag^+(aq) + H_2O(l)$	+1.77
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	-1.68
$As(s) + 3H^+ + 3e^- \rightarrow AsH_3(g)$	-0.23
$Au^+(aq) + e^- \rightarrow Au(s)$	+1.83
$Au^{3+}(aq) + 3e^- \rightarrow Au(s)$	+1.52
$B(OH)_3(aq) + 3H^+ + 3e^- \rightarrow B(s) + 3H_2O(l)$	-0.89
$Ba^{2+}(aq) + 2e^- \rightarrow Ba(s)$	-2.91
$Be^{2+}(aq) + 2e^- \rightarrow Be(s)$	-1.85
$Bi^{3+}(aq) + 3e^- \rightarrow Bi(s)$	+0.32
$Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$	+1.09
$BrO_3^-(aq) + 5H^+ + 4e^- \rightarrow HBrO(aq) + 2H_2O(l)$	+1.45
$2BrO_3^-(aq) + 12H^+ + 10e^- \rightarrow Br_2(aq) + 6H_2O(l)$	+1.48
$BrO_4^-(aq) + 2H^+ + 2e^- \rightarrow BrO_3^-(aq) + H_2O(l)$	+1.85
$C(s) + 4H^+ + 4e^- \rightarrow CH_4(g)$	+0.13
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$	-2.76
$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s)$	-0.40
$CH_3OH(aq) + 2H^+ + 2e^- \rightarrow CH_4(g) + H_2O(l)$	+0.50
$Cl_2(l) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$ClO_2(g) + H^+ + e^- \rightarrow HClO_2(aq)$	+1.19
$CO(g) + 2H^+ + 2e^- \rightarrow C(s) + H_2O(l)$	+0.52
$CO_2(g) + 2H^+ + 2e^- \rightarrow CO(g) + H_2O(l)$	-0.11
$CO_2(g) + 2H^+ + 2e^- \rightarrow HCOOH(aq)$	-0.11
$2CO_2(g) + 2H^+ + 2e^- \rightarrow H_2C_2O_4(aq)$	-0.43
$2ClO_3^-(aq) + 12H^+ + 10e^- \rightarrow Cl_2(g) + 6H_2O(l)$	+1.49
$ClO_3^-(aq) + 2H^+ + 10e^- \rightarrow ClO_2(g) + H_2O(l)$	+1.18
$Co^{2+}(aq) + 2e^- \rightarrow Co(s)$	-0.28

$Co^{3+}(aq) + e^- \rightarrow Co^{2+}(aq)$	+1.92
$CoO_2(s) + 4H^+ + e^- \rightarrow Co^{3+}(aq) + 2H_2O$	+1.42
$Cr_2O_7^{2-}(aq) + 14H^+ + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O$	+1.38
$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$	-0.74
$Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(s)$	-0.42
$Cs^+(aq) + e^- \rightarrow Cs(s)$	-2.92
$Cu^+(aq) + e^- \rightarrow Cu(s)$	+0.52
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$Cu^{2+}(aq) + e^- \rightarrow Cu^+(s)$	+0.16
$F_2(g) + 2H^+ + 2e^- \rightarrow 2HF(aq)$	+3.05
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	-0.44
$Fe^{3+}(aq) + 2e^- \rightarrow Fe^+(s)$	+0.77
$Fe^{3+}(aq) + 3e^- \rightarrow Fe(s)$	-0.04
$[Fe(CN)_6]^{3-}(aq) + e^- \rightarrow [Fe(CN)_6]^{4-}(aq)$	+0.36
$Ga^{3+}(aq) + 3e^- \rightarrow Ga(s)$	-0.53
$Ge(s) + 4H^+ + 4e^- \rightarrow GeH_4(g)$	-0.29
$Ge^{4+}(aq) + 4e^- \rightarrow Ge(s)$	+0.12
$GeO(s) + 2H^+ + 2e^- \rightarrow Ge(s) + H_2O(l)$	+0.26
$GeO_2(s) + 2H^+ + 2e^- \rightarrow GeO(s) + H_2O(l)$	-0.37
$2H^+ + 2e^- \rightarrow H_2(g)$	0.00
$H_3AsO_3(aq) + 3H^+ + 2e^- \rightarrow As(s) + 3H_2O(l)$	+0.24
$H_3AsO_4(aq) + 2H^+ + 2e^- \rightarrow H_3AsO_3(aq) + H_2O(l)$	+0.56
$2HClO(aq) + 2H^+ + 2e^- \rightarrow Cl_2(g) + 2H_2O(l)$	+1.63
$2HIO(aq) + 2H^+ + 2e^- \rightarrow I_2(aq) + 2H_2O(l)$	+1.44
$2Hg^{2+}(aq) + 2e^- \rightarrow Hg_2^{2+}(aq)$	+0.91
$H_2MoO_4(aq) + 6H^+ + 3e^- \rightarrow Mo^{3+}(aq)$	+0.43
$H_2MoO_4(aq) + 2H^+ + 2e^- \rightarrow MoO_2(s) + 2H_2O(l)$	+0.65
$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.83
$H_2O_2(aq) + 2H^+ + 2e^- \rightarrow 2H_2O(l)$	+1.76
$H_3PO_2(aq) + H^+ + e^- \rightarrow P(s) + 2H_2O(l)$	-0.51
$H_3PO_3(aq) + 2H^+ + 2e^- \rightarrow H_3PO_2(aq) + H_2O(l)$	-0.28
$H_3PO_4(aq) + 2H^+ + 2e^- \rightarrow CH_3OH(aq)$	+0.13
$HClO_2(aq) + 2H^+ + 2e^- \rightarrow HClO(aq) + H_2O(l)$	+1.67
$HCOOH(aq) + 2H^+ + 2e^- \rightarrow HCHO(aq) + H_2O(l)$	-0.03
$Hg^{2+}(aq) + 2e^- \rightarrow Hg(l)$	+0.85

$Hg_2^{2+}(aq) + 2e^- \rightarrow Hg(l)$	+0.80
$HMnO_4^-(aq) + 3H^+ + 2e^- \rightarrow MnO_2(s) + 2H_2O(l)$	+2.09
$HNO_2(aq) + H^+ + 2e^- \rightarrow NO(g) + H_2O(l)$	+0.99
$HSeO_4^-(aq) + 3H^+ + 2e^- \rightarrow H_2SeO_3(aq) + H_2O(l)$	+1.15
$HSO_4^-(aq) + 3H^+ + 2e^- \rightarrow SO_2(aq)$	+1.15
$I_2(s) + 2e^- \rightarrow 2I^-(aq)$	+0.54
$I_3^-(s) + 2e^- \rightarrow 3I^-(aq)$	+0.54
$2IO_3^-(aq) + 12H^+ + 10e^- \rightarrow I_2(s) + 6H_2O$	+1.20
$IO_3^-(aq) + 5H^+ + 4e^- \rightarrow HIO(aq) + 2H_2O(l)$	+1.13
$K^+(aq) + e^- \rightarrow K(s)$	-2.93
$Li^+(aq) + e^- \rightarrow Li(s)$	-3.05
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	-2.38
$Mn^{2+}(aq) + 2e^- \rightarrow Mn(s)$	-1.18
$MnO_2(s) + 4H^+ + 2e^- \rightarrow Mn^{2+}(aq) + 2H_2O(l)$	+1.23
$Na^+(aq) + e^- \rightarrow Na(s)$	-2.71
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	-0.26
$NiO_2(s) + 4H^+ + 2e^- \rightarrow Ni^{2+}(aq) + 2H_2O(l)$	+1.59
$NO_3^-(aq) + 6H^+(aq) + 5e^- \rightarrow \frac{1}{2}N_2(g) + 3H_2O(l)$	+1.24
$O_2(g) + 4H^+ + 4e^- \rightarrow 2H_2O(l)$	+1.23
$P(s) + 3H^+ + 3e^- \rightarrow PH_3(g)$	-0.06
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	+0.13
$Pb^{4+}(aq) + 2e^- \rightarrow Pb^{2+}$	+1.69
$PbO_2(s) + 4H^+ + 2e^- \rightarrow Pb^{2+}(aq) + 2H_2O(l)$	+1.47
$PbSO_4(s) + 2e^- \rightarrow Pb^{2+}(aq) + SO_4^{2-}(aq)$	-0.36
$Rb^+(aq) + e^- \rightarrow Rb(s)$	-2.98
$S(s) + 2e^- \rightarrow S^{2-}(aq)$	-0.51
$S_4O_6^{2-}(aq) + 2e^- \rightarrow 2S_2O_3^{2-}(aq)$	+0.09
$S_2O_8^{2-}(aq) + 2e^- \rightarrow 2SO_4^{2-}(aq)$	+2.05
$Se(s) + 2H^+ + 2e^- \rightarrow H_2Se(g)$	-0.11
$Si(s) + 4H^+ + 4e^- \rightarrow SiH_4(g)$	-0.14
$SiO_2(s) + 4H^+ + 4e^- \rightarrow Si(s) + 2H_2O(l)$	-0.91
$Sn(s) + 4H^+ + 4e^- \rightarrow SnH_4(g)$	-1.07
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	-0.13
$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$	+0.15
$SnO(s) + 2H^+ + 2e^- \rightarrow Sn(s) + H_2O(l)$	-0.10

$SnO_2(s) + 2H^+ + 2e^- \rightarrow SnO(s) + H_2O(l)$	-0.09
$SO_2(aq) + 4H^+ + 4e^- \rightarrow S(s) + 2H_2O(l)$	+0.50
$SO_4^{2-}(aq) + 4H^+ + 2e^- \rightarrow H_2SO_3(aq) + H_2O(l)$	+0.17
$Sr^{2+}(aq) + 2e^- \rightarrow Sr(s)$	-2.89
$Ti^{2+}(aq) + 2e^- \rightarrow Ti(s)$	-1.63
$TiO(s) + 2H^+ + 2e^- \rightarrow Ti(s) + H_2O(l)$	-1.31
$Ti^{3+}(aq) + 3e^- \rightarrow Ti(s)$	-0.72
$V^{2+}(aq) + 2e^- \rightarrow V(s)$	-1.13
$V^{3+}(aq) + e^- \rightarrow V^{2+}(aq)$	-0.26
$VO_2(aq) + 2H^+ + e^- \rightarrow VO^{2+}(aq) + H_2O(l)$	+1.00
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	-0.76

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LABORATORY MANUAL

CHEMISTRY II TMS 0434

This Laboratory Manual is a text book for the Tamhidi Programme of Medicine, Dentistry and Science and Technology of the Tamhidi Centre, USIM which whom undergoing the core subject TMS 0434 Chemistry II. There are five experiments carefully selected, which is arranged accordingly correlated to the syllabus of chemistry for foundation studies. The main objectives of the laboratory practices are to provide better understanding of the concepts of chemistry discussed in the lectures and tutorial sessions. During this semester, students will be exposed to the concepts of thermodynamics, reaction rates, electrochemistry and organic chemistry.

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