

INTRODUCTION

The Canadian Engineering Qualifications Board of Engineers Canada issues the Examination Syllabus that includes a continually increasing number of engineering disciplines.

Each discipline examination syllabus is divided into two examination categories: compulsory and elective. A full set of Metallurgical Engineering examinations consists of ten, three-hour examination papers. Candidates will be assigned examinations based on an assessment of their academic background. Examinations from discipline syllabi other than those specific to the candidates' discipline may be assigned at the discretion of the constituent association.

Before writing the discipline examinations, candidates must have passed, or have been exempted from, the Basic Studies Examinations.

The constituent association will supply information on examination scheduling, textbooks, materials provided or required, and whether the examinations are open or closed book.

METALLURGICAL ENGINEERING EXAMINATIONS

GROUP A COMPULSORY EXAMINATIONS

SEVEN REQUIRED

10-Met-A1 Metallurgical Thermodynamics (21-MAT-A1)

Phase relationships and phase rule. First, second and third laws of thermodynamics, enthalpy and heat balances, entropy, free energy, and chemical equilibrium. Solution chemistry and solution models, chemical potential, relationships between phase diagrams and thermodynamic properties. Thermochemical analyses of metallurgical and electrochemical processes. Computational thermodynamics.

10-Met-A2 Metallurgical Rate Phenomena (Suggested Prerequisite: A1) **REWRITTEN**

Transport equations for momentum, heat and mass transfer. Thermodynamic and physical boundary conditions. Interphase mass transfer: gas-solid, gas-liquid, liquid-liquid, and liquid-solid applied to metallurgical systems. Mathematical models. Radiation heat transfer: black and grey body, emissivity and view factors. Heat transfer in casting processes: mould properties, continuous casting. Reactor theory applied to metallurgical operations: mixed flow, plug flow, residence time.

10-Met-A3 Metal Extraction Processes **MINOR TEXT CHANGES**

Principles of mineral processing: comminution, physical separation techniques, flotation, dewatering. Selection of extraction processes. Hydrometallurgy and electrometallurgy including leaching, solution purification, solvent extraction, metal winning and refining. Pyrometallurgical operations including roasting, smelting, converting and refining and refractory issues. Calculations based on flow sheets, heat and mass balances. Environmental impact of processing operations.

10-Met-A4 Structure of Materials

SIMPLIFIED

Structure of metals (description of crystal structures). Analytical methods to determine structure including metallography, X-ray diffraction, and scanning and transmission electron microscopes. Introductory dislocation theory. Elements of grain boundaries. Vacancies. Phases and binary phase diagrams.

10-Met-A5 Mechanical Behaviour and Fracture of Materials (Suggested Prerequisite: A4)

SIMPLIFIED

Tensile response of materials. Elements of dislocation theory. Slip and twinning in crystalline solids. Strengthening mechanisms in metals. High temperature deformation response of crystalline solids. Fracture. Elements of fracture mechanics. Cyclic stress and strain fracture. Fatigue crack propagation.

10-Met-A6 Phase Transformation and Thermal Treatment of Metals and Alloys (Suggested Prerequisite: A4)

REWRITTEN

Annealing of Metals (Recovery, recrystallization, grain growth, secondary recrystallization, and heat treatments based on these phenomena.) Nucleation and growth processes and the solidification of metals. Solidification phenomena in metals. Nucleation and growth kinetics. Precipitation hardening.

10-Met-A7 Corrosion and Oxidation (Suggested Prerequisite: A1)

ADDED (12-MTL-B11)

Basic corrosion theory. Electrochemical corrosion theory. Metallurgical cells. Environmental cells. Stress assisted corrosion. Materials selection. Protective coatings. Corrosion inhibitors. Cathodic and anodic protection. Oxidation.

GROUP B
ELECTIVE EXAMINATIONS

THREE REQUIRED

10-Met-B1 Mineral Processing

MINOR CHANGES TO TEXT

Sources and nature of metallic and industrial minerals of importance. Comminution techniques, size classification. Hydrocyclones, gravity and magnetic separations. Flotation: surface chemistry, reagents, analysis. Tailings disposal, water pollution control, closed circuit operation. Plant design, process analysis and optimization.

10-Met-B2 Hydrometallurgy and Electrometallurgy

(12-MTL-B2)

ELECTROMETALLURGY ADDED

Unit processes of hydrometallurgy: acid, alkaline and pressure leaching. Thermodynamic and kinetic aspects. Pourbaix diagrams. Purification of leach liquors by ion exchange, solvent extraction and selective precipitation operations. Solid-liquid separation techniques. Principles of electrometallurgy.

Recovery of metal values by cementation, electrowinning and refining from aqueous solutions.

Electrolyte preparation, cell potential, effect of additives. Hydrogen precipitation methods. Application of processes for the recovery of copper, nickel, zinc, cobalt, gold and uranium.

10-Met-B3 Ironmaking and Steelmaking

(21-MAT-B3)

MINOR EDITS

Thermodynamics and kinetics of iron and steelmaking reactions. Direct reduction processes. Blast furnace operations. Chemical properties of fluxes, slags and refractories. Converter processes and electric furnace steelmaking. Treatment of hot metal, ladle metallurgy including desulfurization, deoxidation, inert gas and vacuum treatment. Continuous casting. Secondary refining processes including AOD, VAD, VOD, VAR, and ESR. Analysis of new and emerging steelmaking technologies. Environmental control.

10-Met-B4 Non-Ferrous Extractive Metallurgy

(12-MTL-B4)

MINOR EDITS

The application of principles of thermodynamics, kinetics, and transport phenomena to the extraction and refining of non-ferrous metals using pyrometallurgical processes. Production of copper, nickel, lead, and zinc from sulphides. Converting and flash smelting operations. Production of aluminum and magnesium using fused salt electrolysis. Reduction cell operation. Production of refractory metals by chlorination and purification. Recent developments in non-ferrous pyrometallurgy. Environmental impact.

10-Met-B5 Metal Fabrication

(21-MAT-B5)

MINOR EDITS

Fundamentals of solidification: phase diagrams, cooling curves, cast structures, solidification shrinkage, molten metal characteristics. Casting methods including ingot casting, continuous casting, sand casting, die casting, investment casting, counter gravity, lost foam, mould casting, squeeze and semi-solid casting. Hot working: hot rolling, extrusion, and forging. Bending and sheet metal operations: roll bending and forming, shearing operations, stretch forming and drawing, hydroforming, and superplasticity. Powder metallurgy processes.

10-Met-B6 Physical Metallurgy of Iron and Steel (12-MTL-B6) REWRITTEN

Iron-Carbon Alloys (Fe-Fe₃C Alloys system and isothermal transformation of austenite to ferrite and cementite and martensite, annealing and normalizing, cold working and process annealing, tempering, austempering and martempering). Carbon steels including microalloyed steels. Alloy steels. Stainless steels. Cast irons. Tool steels. Surface hardening and modification.

10-Met-B7 Physical Metallurgy of Non-Ferrous Metals and Alloys (12-MTL-B7) REWRITTEN

Aluminum and its alloys. Copper and its alloys. Titanium and its alloys. Nickel and Cobalt alloys. Magnesium and Zinc alloys. Refractory metals and alloys and structural intermetallics.

10-Met-B8 Ceramic Materials (21-MAT-B6) REWRITTEN

Bonding in ceramics. Ceramic structures. Effect of chemical forces and structure on physical properties. Defects in ceramics. Diffusion and electrical conductivity. Phase equilibria. Sintering and grain growth. Mechanical properties: fast fracture, creep, slow crack growth and fatigue. Thermal stresses and thermal properties. Dielectric properties.

10-Met-B9 Structure and Properties of Polymers (21-MAT-B7) REWRITTEN

Chain architecture: chain dimensions, Gaussian segment density distribution, polymer conformation. Molar mass determination: osmometry, light scattering, gel permeation chromatography, capillary viscometry. Polymer phase equilibria: solvent quality, polymer blending. Polymer structure/transitions: melting and glass transition temperatures, free volume. Crystallization: crystal structure, fractional crystallinity. Mechanical properties: testing methods, compliance, viscoelasticity, dynamic testing, time-temperature superposition, mastercurve, rubber elasticity, crazing. Polymer flow properties: viscosity, rheology, shear thinning, analysis of flow fields. Polymer processing techniques,

10-Met-B10 Advanced Electronic Materials (12-MTL-B10) NEW

Band theory: energy levels in solids, effective mass, Fermi-Dirac statistics. Semiconductors: doping, activation, diffusion, P-n junctions, and solar cells. Dielectrics and polarization: capacitance, dielectric materials, Lorentz field, dielectric breakdown, piezoelectricity, ferroelectricity and pyroelectricity. Magnetism: field intensity, permeability, exchange interaction, saturation magnetization, magnetic domains and anisotropy, hysteresis loop. Superconductivity: Meissner effect, superconducting materials, critical field and current density, BCS theory. Metals: contact potential, Seebeck and thermocouple effect, thermoelectrics, electromigration.

10-Met-A1 Metallurgical Thermodynamics**Prime Text**

Gaskell, David, Introduction to Metallurgical Thermodynamics. CRC Press, 2008. ISBN: 9781591690436. Chapters 2, 3, 6, 8-14.

Supplementary References

De Hoff, Robert, Thermodynamics in Materials Science. Second edition, CRC Press, 2006. ISBN: 979849340659

Lee, H. G., Chemical Thermodynamics for Metals and Materials. Imperial College Press, 2001. ISBN: 1-86094-X.

Rosenquist, T., Principles of Extractive Metallurgy. Second edition, Tapir Academic Press, 2004. ISBN: 9788251919227.

10-Met-A2 Metallurgical Rate Phenomena**Prime Text**

Poirier, D.R., and Geiger, G.H., Transport Phenomena in Material Processing. TMS Publications, 1998. ISBN: 0873392752. Chapters 1, 2, 3, 6-15.

Supplementary References

Gaskell, D.R., Transport Phenomena in Materials Engineering. Prentice-Hall, 1991. ISBN: 97800234070208.

Guthrie, R.I.L., Engineering in Process Metallurgy. Oxford University Press, 1992. ISBN: 0198563671.

Powell IV, A., "Transport Phenomena in Materials Engineering". MIT Open Courseware. <http://ocw.mit.edu/courses/materials-science-and-engineering/3-185-transport-phenomena-in-materials-engineering-fall-2003/>.

Szekely, J. and N.J. Themelis, Rate Phenomena in Process Metallurgy, Wiley-Interscience, 1971. ISBN: 0471843030.

10-Met-A3 Metal Extraction Processes**Prime Text**

Rosenquist, T. Principles of Extractive Metallurgy. Tapir Academic Press, 2004. ISBN: 9788251919227. Chapters 4-14.

Supplementary References

Gilchrist, J.D., Extraction Metallurgy. (3rd edition) Pergamon Press, 1989. ISBN: 0-08-036611-2.

Ghosh, A. and H. S. Ray, Principles of Extractive Metallurgy. New Age International, 1991. ISBN: 8122403220.

Habashi, F., Principles in Extractive Metallurgy: General Principles. Gordon & Breach Science Publishers, 1969. ISBN: 0677017707.

Napier-Munn, T. and B.A. Wills, Mineral Processing Technology (7th edition). Butterworth-Heinemann, 2006. ISBN: 0750644508

10-Met-A4 Structure of Materials

Prime Text

Reed-Hill, R.E. and R. Abbaschian, Physical Metallurgy Principles. (3rd edition) PWS Kent Publishers, Boston, 1992. ISBN 0534921736. Chapters 1-4, 6, 7, 11 and 14

Supplementary References

Barrett, C.S. and T.B. Massalski, Crystallographic Methods, Principles and Data. (3rd revised) Pergamon, 1980.

Cullity, BD and Stock, SR., Elements of X-ray Diffraction 3rd Edition. Prentice Hall, Upper Saddle River NJ, 2001 ISBN 0-201-61091-4 Chaps 1-3.

Flinn, R.A. and P.K. Trojan, Engineering Materials and Their Applications. (4th edition), Houghton Mifflin Company, Boston, 1990.

Shackelford, J.F., Introduction to Materials Science for Engineers. Latest edition, MacMillan Publishing Company, New York.

10-Met-A5 Mechanical Behaviour and Fracture of Materials

Prime Text

Hertzberg R.W., Deformation and Fracture Mechanics of Engineering Materials. (4th edition) John Wiley, New York, 1996. ISBN 0-471-01214-9. Chaps 1-5, 7, 8, 12 and 13.

Supplementary References

Courtney, T.H., Mechanical Behaviour of materials, 2nd Edition. 2000. ISBN #0-070-28594-2.

Dieter, G., Mechanical Metallurgy. (3rd edition) McGraw-Hill Book Co., New York, 1986. ISBN 0070168938.

10-Met-A6 Phase Transformation and Thermal Treatment of Metals and Alloys

Prime Text

Reed-Hill, R.E. and R. Abbaschian, Physical Metallurgy Principles. (3rd edition), PWS Kent, Boston, 1991. ISBN 0534921736. Chapters 8, 14, 15, and 16.

Supplementary References

ASM Handbook (Revised). Vol. 4, Heat Treating.

ASM Handbook. Vol. 2, Properties and Selection Nonferrous Alloys.

ASM Handbook. Vol. 1. Properties and Selection Iron and Steels.

Brooks, C.R., Heat Treatment Structure and Properties of Nonferrous Alloys. American Society for Metals, Metals Park, OH, 44073, USA, 1984.

Krauss, G., Steels: Heat Treatment Processing Principles. ASM International, 1990.

10-Met-A7 Corrosion and Oxidation***Prime Text***

Bradford SA, Corrosion Control (2nd edition), Casti Publishing, Edmonton. ISBN 1-894038-58-4. Chapters 1-6, 9-12, 14.

10-Met-B1 Mineral Processing***Prime Text***

Napier-Munn, T. and B.A. Wills, Mineral Processing Technology. Butterworth-Heinemann, 2006. ISBN: 0750644508. Chapters 2-16.

Supplementary References

Kelly, E.G. and D.J. Spottiswood, Introduction to Mineral Processing. Wiley Interscience, 1992. ISBN-10: 0471033790.

Mular, A.L. and D. Halbe and D. Barrat, Mineral Processing Plant Design, Practice and Control. Society for Mining, Metallurgy and Exploration, 1992. ISBN: 0873352238.

10-Met-B2 Hydrometallurgy and Electrometallurgy***Prime Text***

Jackson, E, Hydrometallurgical Extraction and Reclamation. Ellis Horwood Limited, 1986. Halstead Press, John Wiley & Sons. SBN: 0-7458-0048-3 and 0-470-2034-5. Chapters: 1, 2, 3, 4, 5.

Supplementary References

Habashi, F., Textbook of Hydrometallurgy. Les copies de la capitale inc., 1995. Distributed by Laval University Bookstore. ISBN : 2-980-3247-7-9.

Peters, E. G. L. Bolton, D.B. Dreisinger and B. Conard, Hydrometallurgy: Theory and Practice. TMS-AIME Press, 1992. ISBN: 0444986562.

Rosequist, T., Principles of Extractive Metallurgy. Tapir Academic Press, 2004. ISBN: 9788251919227.

10-Met-B3 Ironmaking and Steelmaking***Prime Text***

Turdogan, E.T., Fundamentals of Steelmaking. Woodhead Publishing Limited, 1996. ISBN: 1861250045. Chapters: All.

Supplementary References

Fruehan, R.J., The Making Shaping and Treating of Steel. 11th edition, ironmaking Volume. AIST Publications, 1992. ISBN: 978-0-930767-03-7.

Fruehan, R.J., The Making Shaping and Treating of Steel. 11th edition, Steelmaking and Refining Volume. AIST Publications, 1992. ISBN: 978-0-930767-02-0.

Fruehan, R.J. and E.T. Turkdogan, Proceedings of the Ethem T. Turkdogan Symposium: Fundamentals and analysis of New and Emerging Steelmaking Technologies, Pittsburgh, 1994. The Metals and Materials Society, Iron and Steel Society

10-Met-B4 Non-Ferrous Extractive Metallurgy

Prime Text

Gill, C.B., Non-Ferrous Extractive Metallurgy. John Wiley and Sons, 1998. ISBN: 0894642642. Chapters: all.

Supplementary References

Davenport, W.G., Extractive Metallurgy of Copper. Pergamon Press, Oxford, 1994. ISBN: 0080421245.

Evans, J.W. and Z.C. Dejonghe, The Production of Inorganic Material. TMS Press, Warrendale, 2002. ISBN: 0873395417.

Rosenquist, T., Principles of Extractive Metallurgy. Tapir Academic Press, 2004. ISBN: 9788251919227.

10-Met-B5 Metal Fabrication

Prime Text

DeGarmo, E. Paul, J.T. Black, and Ronald A. Kohser, Materials and Processes in Engineering, 10th Edition. 2007. ISBN: 0-470-05512-X. Chapters 4, 7, 13-19.

Supplementary References

Kapakjian, Serope and Steve Schmid, Manufacturing Engineering and Technology, 6th edition, Prentice Hall. 2009. ISBN # 0136081681.

10-Met-B6 Physical Metallurgy of Iron and Steel

Prime Text

Smith, W.F., Structure and Properties of Engineering Alloys (2nd edition), McGraw Hill, New York, 1993. Chapters 1-4, 7-9 and 14.

Supplementary References

Krause, G., Steels: Heat Treatment and Processing Principles. (3rd edition) ASM Int., 1990 ISBN 087170370X

Metals Handbook Volume 4 – Heat Treating (10th edition) ASM Materials Park, 1991.

Metals Handbook Volume 1 – Properties and Selection: Iron, Steels and High Performance Alloys. (10th edition), AMS, Materials Park, Ohio, 1990 ISBN 0871703777.

10-Met-B7 Physical Metallurgy of Non-Ferrous Metals and Alloys**Prime Text**

Smith, W.F., Structure and Properties of Engineering Alloys, 2nd edition. McGraw Hill, New York, 1993. Chapters 5-6, and 10-13.

10-Met-B8 Ceramic Materials**Prime Text**

Barsoum, M.W., Fundamentals of Ceramics. IOP Publishing, Bristol, 2003. ISBN #0 07503 0902 4. Chapters 1-4, 6-8, and 10-14.

Supplementary Reference

Kingery, W.D., H.K. Bowen, and D.R. Uhlmann, Introduction to Ceramics. (2nd edition) Wiley, New York, 1976. ISBN 0471478601.

10-Met-B9 Structure and Properties of Polymers**Prime Text**

Young, R.J. and P.A. Lovell. Introduction to Polymers. CRC Press, 2nd edition, 1991. Chapters 1, 3-5.

Supplementary Reference

McCrum, N.G., Buckley, C.P. Bucknall, C.B. "Principles of Polymer Engineering", Oxford, 2nd ed., 1997.

10-Met-B10 Advanced Electronic Materials**Prime Text**

Kasap, S.O., Principles of Electronic Materials and Devices, 3rd edition. McGraw-Hill Science, 2002. Chapters 4-8.

**METALLURGICAL ENGINEERING EXAMINATIONS
SYLLABUS**

**GROUP A
COMPULSORY EXAMINATIONS (6 REQUIRED)**

98-Met-A1 Metallurgical Thermodynamics

First, second, and third laws, enthalpy and heat balances, entropy, free energy, chemical equilibrium, equilibrium constant, phase rule, solution chemistry, chemical potential, activities. Application of the laws of thermodynamics to metallurgical processes, electrochemistry, interfacial phenomena, extraction and refining of materials, corrosion, and electrodeposition. Computational thermodynamics.

98-Met-A2 Metallurgical Rate Phenomena

Fluid flow, heat transfer, mass transfer as applied to metallurgical processes. Laws of viscosity, conduction and diffusion. Equations for the conservation of heat, mass and momentum transfer. Process engineering metallurgy and reactor theory (plug flow and well-mixed) as applied to hydrometallurgical, pyrometallurgical, electrochemical, and corrosion processes.

98-Met-A3 Metal Extraction Processes

Principles of mineral dressing: comminution, physical separation techniques, flotation, dewatering.

Extraction processes: hydrometallurgy and electrometallurgy including leaching, solution purification, solvent extraction, metal winning, refining; pyrometallurgy including roasting, smelting, converting, and refining. Fuels, furnaces, metallurgical reactors, refractories, energy efficiency. Calculations based on flow sheets, heat and mass balances. Environment protection. Automatic control.

98-Met-A4 Structure of Materials

Atomic and molecular structure. Metallic, ionic, covalent and Van der Waals, Crystal structure, space lattices and Miller indices. Crystalline and non-crystalline (amorphous). Solidification (crystallisation) and associated microstructures of cast metals and phenomena of grain boundaries. Observations of material structure (X-ray techniques, metallography, optical and electron microscopy). Defects in solids, dislocation and slip, vacancies and diffusion. Basic mechanisms of deformation processes of materials. Phase diagrams (solid solution systems, eutectic and eutectoid systems, monotectic peritectic reaction, intermetallic compounds). Application of lever rule to phase proportions in common single- and binary-phase systems.

98-Met-A5 Mechanical Behaviour and Processing and Performing of Materials

Mechanical properties and mechanical testing. Stress-strain-time relations, work hardening, toughness, fatigue, and stress-rupture. Principles in the forming of materials: sintering, melting and casting, extrusion, injection moulding, drawing, rolling and forging. Moulding techniques for particulate and fibre reinforcing. Theoretical strength, defects and fracture mechanics theory. Environmental aspects and materials performance; stress corrosion, corrosion fatigue, hydrogen embrittlement, degradation due to nuclear and ultra-violet radiation. Other degradation and service failure and their prevention (wear, friction, etc.).

98-Met-A6 Thermal Treatment of Metals and Alloys

The cold-worked state; recovery, recrystallization, grain growth, secondary recrystallization, and heat treatments based on these phenomena. Nucleation and growth kinetics. Precipitation in alloy systems and precipitation hardening. The iron-carbon alloy system and the eutectoid reaction in Fe-C alloys. The hardening of steel.

GROUP B
ELECTIVE EXAMINATIONS (3 REQUIRED)

98-Met-B1 Mineral Processing

Minerals of economic importance (metallic and industrial). Comminution techniques, size classification, hydrocyclones. Flotation: surface chemistry, reagents, on-stream analysis, process optimization, oxide flotation. Gravity and magnetic separations. Tailings disposal, water pollution control, closed circuit operation. Mineral processing plant design. Process analysis, simulation, optimization, and control.

98-Met-B2 Hydrometallurgy

Unit processes in hydrometallurgy: acid, alkaline, and pressure leaching methods. Thermodynamic and kinetic aspects. Purification of leach liquors by ion exchanges, solvent extraction, and selective precipitation operations. Solid-liquid separation techniques. Recovery of metal values by cementation, electrowinning, and hydrogen precipitation methods.

98-Met-B3 Iron and Steelmaking

Fundamental thermodynamic and kinetic aspects of iron and steelmaking reactions. Composition, structure, properties and performance of fluxes, slags and refractories. Direct reduction processes. Ironmaking in the blast furnace. External treatment of hot metal. Converter processes and electric furnace steelmaking. Ladle metallurgy operations including deoxidation, desulfurization, sulfide shape control, inert gas rinsing, and vacuum reactors. Factors affecting the formation and removal of inclusions. Secondary refining processes including AOD, VAD, VOD, VAR, and ESR. Ingot manufacture and continuous casting. Plasma applications in iron and steelmaking. Environmental control, automation, energy minimization, and process optimization.

98-Met-B4 Non-Ferrous Extractive Metallurgy

The application of the principles of thermodynamics, kinetics, and heat and mass transfer to the extraction and refining of non-ferrous metals. These include the common base metals (copper, nickel, lead, and zinc), light metals (magnesium, aluminum), and refractory metals (titanium, zirconium, and chromium). Recent process developments in non-ferrous metallurgy, for example flash smelting. Environmental problems associated with the non-ferrous industry.

98-Met-B5 Metal Fabrication

Casting methods including ingot casting, continuous casting, sand casting, die casting, investment casting, and shell moulding. Cast structures, grain refinement and casting defects. Hot working: hot rolling, extrusion, and forgings. Cold working: cold rolling, pressing, impact extrusion, drawing,

and sheet metal forming. Joining techniques: welding methods, weld defects, weld inspection, brazing, and soldering. Powder metallurgy processes.

98-Met-B6 Physical Metallurgy of Iron and Steel

The Fe-C diagram. Structures of slowly cooled steels. Specialized heat treatments including full annealing, normalizing, process annealing. Batch and continuous annealing. Martensite formation: quenching and tempering. Bainite formation. Austempering and martempering. TTT curves. Hardenability and the Jominy test. Alloy steels, HSLA steels, and stainless steels. Surface hardening. Cast irons, their structure and heat treatment.

98-Met-B7 Physical Metallurgy of Non-Ferrous Metals and Alloys

Aluminum and its alloys: properties, effects of alloying elements, heat treatment, modification of properties, corrosion resistance.

Magnesium and its alloys: cast and wrought alloys C effect of alloying elements, grain refinement, corrosion resistance.

Copper and its alloys: properties C brasses, bronzes.

Low melting point alloys: diecasting alloys, type metals, solder, bearing metals. Nickel-base super alloys. Cobalt base alloys. Titanium.

98-Met-B8 Ceramic Materials

Crystal structure of ceramics. Glass formation and structure of oxide glasses. Processing and shaping of crystalline materials and glasses. Phase diagrams in ceramic systems. Microstructure of ceramics. Mechanical properties of ceramics: strength, fracture toughness, creep, fatigue, thermal shock resistance, viscous flow, tempering and annealing of glass. Thermal, optical, electrical, and magnetic properties of ceramic materials.

98-Met-B9 Polymers and Fibre-Reinforced Polymers

Fundamental properties and applications of polymers; characterization of polymers; properties of polymers, including crystallization, thermal and oxidative degradation, specific heat, thermal conductivity, and thermal expansion; polymer processing techniques; failure mechanisms; and introduction to fibre-polymer composites.

The Association of PROFESSIONAL ENGINEERS AND GEOSCIENTISTS of British Columbia

1998 METALLURGICAL ENGINEERING SYLLABUS

Checklist for Self Evaluation
(Not required for candidates who are assigned
confirmatory exams)

Name: _____

Exam Number	Exam Name	Applicant's Self-Evaluation - Course Equivalent	For Office Use Only
Basic Studies (6 Required)			
98-BS-1	Mathematics		
98-BS-2	Probability and Statistics		
98-BS-6	Mechanics of Materials		
98-BS-7	Mechanics of Fluids		
98-BS-10	Thermodynamics		
98-BS-11	Properties of Materials		
Basic Studies (2 required)			
98-BS-3	Statics and Dynamics		
98-BS-4	Electric Circuits and Power		
98-BS-5	Advanced Mathematics		
98-BS-8	Digital Logic Circuits		
Group A (6 required)			
98-Met-A1	Metallurgical Thermodynamics		
98-Met-A2	Metallurgical Rate Phenomena		

98-Met-A3	Metal Extraction Processes		
98-Met-A4	Structure of Materials		
98-Met-A5	Mechanical Behaviour and Processing and Performing of Materials		
98-Met-A6	Thermal Treatment of Metals and Alloys		
Group B (3 Required)			
98-Met-B1	Mineral Processing		
98-Met-B2	Hydrometallurgy		
98-Met-B3	Iron and Steel making		
98-Met-B4	Non-Ferrous Extractive Metallurgy		
98-Met-B5	Metal Fabrication		
98-Met-B6	Physical Metallurgy of Iron and Steel		
98-Met-B7	Physical Metallurgy of Non-Ferrous Metals and Alloys		
98-Met-B8	Ceramic Materials		
98-Met-B9	Polymers and Fibre-Reinforced Polymers		
Complementary Studies (All Required)			
98-CS-1	Engineering Economics		
98-CS-2	Engineering in Society - Health, Safety, and the Environment		
98-CS-3	Management Concepts for Engineers		

METALLURGICAL ENGINEERING – SUGGESTED TEXT LISTING

98-Met-A1 - Metallurgical Thermodynamics

David. Gaskell, Introduction to Metallurgical Thermodynamics, latest edition, Taylor & Francis. ISBN # 0-89116-486-3

C.B. Alcock and others, Metallurgical Thermo-Chemistry, latest edition, Pergamon Press, Oxford.

T. Rosenquist, Principles of Extractive Metallurgy, latest edition, McGraw-Hill.

98-Met-A2 - Metallurgical Rate Phenomena

D.R. Gaskell, An Introduction to Transport Phenomena in Materials Engineering, Maxwell, MacMillan Canada.

R.I.L. Guthrie, Engineering in Process Metallurgy, Clarendon Press, Oxford.

G.H. Geiger and D.R. Poirer, Transport Phenomena in Metallurgy, Addison-Wesley.

Szekely and N.J. Themelis, Rate Phenomena in Process Metallurgy, Wiley Interscience.

98-Met-A3 - Metal Extraction Processes

Peter Hayes, Process Selection In Extractive Metallurgy ISBN# 0-9589197-1-2

Terkel Rosenqvist, Principles of Extractive Metallurgy, latest edition, ISBN # 0-07-053910-3

J.D. Gilchrist, Extraction Metallurgy, latest edition, Pergamon Press.
(ISBN 0-08-036612-0, Hard Cover; 0-08-636611-2, Flexi Cover.) (out of print)

98-Met-A4 - Structure of Materials

J.F. Shackelford, Introduction to Materials Science for Engineers, latest edition, MacMillan Publishing Company, New York.

R.A. Flinn and P.K. Trojan, Engineering Materials and Their Applications, latest edition, Houghton Mifflin Company, Boston.

98-Met-A5 - Mechanical Behaviour and Processing and Performing of Materials

T.H. Courtney, Mechanical Behaviour of Materials, 2nd Edition, 2000. ISBN #0-070-28594-2

George E. Dieter Mechanical Metallurgy latest edition, McGraw Part 4, 15-20 ISBN#0-07-016893-8

98-Met-A6 - Thermal Treatment of Metals and Alloys

C.R. Brooks, Heat Treatment Structure and Properties of Nonferrous Alloys, American Society for Metals, Metals Park, OH, 44073, U.S.A., 1984.

ASM Handbook (Revised), Vol. 4, Heat Treating.

ASM Handbook, Vol.2, Properties and Selection Nonferrous Alloys.

ASM Handbook, Vol.1, Properties and Selection Iron and Steels.

G. Krauss, Steels: Heat Treatment Processing Principles, ASM International, 1990.

98-Met-B1 - Mineral Processing

B.A. Wills, Mineral Processing Technology, 5th Edition, Pergamon Press, 1992.

E.G. Kelly and D.J. Spottiswood, Introduction to Mineral Processing, Wiley Interscience, 1992.

Handbook of Mineral Processing, AIME, 1985.

A.L. Mular and R.B. Bhappu, Mineral Processing Plant Design, 2nd Edition, AIME, 1980.

98-Met-B2 - Hydrometallurgy

Eric Jackson, Hydrometallurgical Extraction and Reclamation, Ellis Harwood Ltd., John Wiley and Sons Inc., 1986.
(ISBN 0-85312-568-6, Hard Cover; 0-7458-0048-3, Soft Cover)

98-Met-B3 - Iron and Steelmaking

H.E. McGannon, The Making, Shaping and Treating of Steel, 10th Edition, U.S. Steel Co. Association of Iron and Steel Engineers, Three Gateway Center, Suite 2350, Pittsburgh, PA, 15222, U.S.A. (Tel: 412-281-6323)

98-Met-B4 - Non-Ferrous Extractive Metallurgy

T. Rosenquist, Principles of Extractive Metallurgy, 2nd Edition, McGraw-Hill, 1983.

J.W. Evans and Z.C. DeJonghe, The Production of Inorganic Material, Collier MacMillan Canada, 1991.

J.D. Gilchrist, Extraction Metallurgy, 3rd Edition, Pergamon Press, 1989.

98-Met-B5 - Metal Fabrication

John A. Schey, Introduction to Manufacturing Processes, latest edition, McGraw-Hill, ISBN # 0-07-055279-7.

John Campbell, Casting Technology: "Castings", Butterworth-Heinemann, Ltd., ISBN # 0-7506-10727, 1991.

R.M. German, For Powder Metallurgy: "Powder Metallurgy Science", Metal Powder Industries Federation, Princeton, New Jersey, ISBN # 0-918404-60-6, 1984.

K. Easterling, For Welding: "Introduction to the Physical Metallurgy of Welding", latest edition, Butterworth-Heinemann, Ltd., ISBN # 0-7506-03941.

98-Met-B6 - Physical Metallurgy of Iron and Steel

G. Kraus, Heat Treatment and Processing Principles, ASM International, 1990.

ASM Handbook, Vol. 1, Properties and Selection, latest edition.

ASM Handbook (Revised), Vol. 4, Heat Treating.

The Making Shaping and Treatment of Steel, latest edition, Association of Iron and Steel Engineers.

NOTE: Books are available from Canada Engineering Data Centre, 4444 Fieldgate Dr., Mississauga, ON, L4W 4T6, Tel: 416-624-1058.

98-Met-B7 - Physical Metallurgy of Non-Ferrous Metals and Alloys

Charlie R. Brooks, Non-Ferrous Alloys, Heat Treatment, Structure and Properties, ASM International, 1982.

98-Met-B8 - Ceramic Materials

Ceramics and Glasses, Engineered Materials Handbook, Vol. 4, ASM International, 1987, ISBN 0-87170-282-7

David W. Richerson, Modern Ceramic Engineering, latest edition, Marcel Dekker, Inc. ISBN 0-8247-8634-3

James S. Reed, Introduction to the Principles of Ceramic Processing, John Wiley & Sons Inc., 1988 ISBN 0-471-84554-X.

98-Met-B9 - Polymers and Fibre-Reinforced Polymers

McCrum, Buckley, Bucknall Principles of Polymer Engineering 1988 Oxford University Press Tel: 416-441-2941

Updated: January 2002