CIHM Microfiche Series (Monographs) ICMH Collection de microfiches (monographies)



Canadian Institute for Historical Microreproductions / Institut canadian de microreproductions historiques



#### Technical and Bibliographic Notes / Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter eny of the images in the reproduction, or which may significantly change the usual method of filming, are checked below. 5\*\*

.

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les déteils de cet exempleire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

32 X

Coverture endommagie       Pages damaged/         Coverture endommagie       Pages endommagies         Coverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Coverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Coverture restaurée et/ou pelliculée       Pages discoloured, stained or foxed/         Courser title missing/       Le titre de couverture manque       Pages discoloured, stained or foxed/         Coloured ink (i.e. other then blue or black)/       Pages detached/       Pages detached/         Coloured plates and/or illustrations/       Pages detached/       Transparence         Coloured plates and/or illustrations/       Showthrough/       Transparence         Coloured plates and/or illustrations/       Duality of print varies/       Quality of print varies/         Planches et/ou illustrations/       Duality of print varies/       Quality of print varies/         Planches et/ou illustrations/       Duality of print varies/       Quality of comprend un (des) index         Tight binding may cause shadows or distortion along interior margin/       Comprend un (des) index       Title on header taken from:/         Le titre de la liver alon paresent dia us to take here base base base monited from filming/       It takes there were possible, ces pages n'ont pas att filmées.       Caption of issue/         Bank leaves added during retoration may appeer within	Covers damaged/         Covers restored and/or laminated/         Covers restored and/or laminated/         Covers restored and/or laminated/         Covers the missing/         La titre de couverture manque         Coloured maps/         Coloured maps/         Coloured ink (i.e. other then blue or black)/         Encre de couleur (i.e. autre que bleue ou noire)         Coloured plates and/or illustrations/         Planches et/ou illustrations and distortion along interior margin/         La tite de laive documents         Tight binding may cause shadows or distortion along interior margin/         La teiture social text. Whenever possible, these have been omitted from filming/         Is peut que certaines pages blanches aloutes         Diss divers restaration apaperessent dions texts, mais, lorsque cela text pospressi	×	14X		TT			TT				
Covers damaged/         Covers damaged/         Covers restored and/or laminated/         Covers restored and/or laminated/         Cover title missing/         Cover title missing/         La titre de couverture manque         Coloured meps/         Coloured ink (i.e. other then blue or black)/         Coloured jates and/or illustrations/         Planches et/ou illustrations en couleur         Bound with other material/         Relié avec d'autres documents         Tight binding may cause shadows or distortion along interior margin/         La reliver serice peut causer de l'ombre ou de la distorsion le long de la marge intérieure         Blank leaves added during restorstion may appear within the text. Whenever possible, these have been omitted from filming/         Il se peut que certaines pages hlanches ajoutées lors d'une restauration apparesisent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.         Additional comments:/	Colument of the secondaur       Pages de couleur         Converture de couleur       Pages de couleur         Covers restored and/or laminated/       Pages de couleur         Cover title missing/       La titre de couverture manque         Coloured meps/       Pages décolorées, tachetés ou piquées         Coloured ink (i.e. other then blue or black//       Pages décolorées, tachetés ou piquées         Coloured plates and/or illustrations/       Pages détachées         Coloured plates and/or illustrations en couleur       Qualité inégale de l'impression         Coloured plates and/or illustrations en couleur       Quality of print varies/         Planches et/ou illustrations en couleur       Quality of print varies/         Planches et/ou illustrations en couleur       Quality of print varies/         Relie avec d'autres documents       Continuous pagination/         Titet binding may cause shadows or distortion along interior margin/       Comprend un (des) index         Is peut que certaines pages blanches ajoutées       Tite on header taken from:/         Le titre de la marge partiesent dans te texte, mais, loraque cela érsit possible, ces pages n'ont pas été filmées.       Masthead/ </td <td></td> <td></td> <td></td> <td>18X</td> <td></td> <td>22 X</td> <td></td> <td>26 X</td> <td></td> <td>30 X</td>				18X		22 X		26 X		30 X	
Covers damaged/         Covers damaged/         Covers restored and/or laminated/         Coverture restaurée et/ou pelliculée         Cover title missing/         Le titre de couverture manque         Coloured mept/         Coloured mept/         Coloured into title, autre que bleue ou noire)         Coloured plates and/or illustrations/         Pages detached/         Pages detached/         Pages detached/         Pages detached/         Coloured plates and/or illustrations/         Planches et/ou illustrations en couleur         Bound with other material/         Relié avec d'autres documents         Tight binding may cause shadows or distortion along interior margin/         La reliure servée peut causer de l'ombre ou de la distorsion le long de la marge intérieure         Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/         Il se peut que certaines pages blanches ajoutées lors d'une restauration appareissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas set filmées.         Cational comments:/         Cational comments:/         Commentaires supplémentaires:	Couver use of couleur       Pages de couleur         Couverture endommagée       Pages de couleur         Couverture endommagée       Pages de couleur         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages détachées         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured plates and/or illustrations/       Pages détachées         Coloured plates and/or illustrations       Oualité inégale de l'impression         Coloured plates and/or illustrations en couleur       Oualité inégale de l'impression         Bound with other material/       Continuous pagination/         Planches et/ou illustrations en couleur       Continuous pagination/         Bound with other material/       Continuous pagination/         Reliè avec d'autres documents       Includes index(sl)/         Comprend un (des) index       Title on header taken from:/         Le titre de l'a mines       Title page of issue/         Page de titre de la livraison       Caption of issue/         Is peut que ceta était p	• • •••••										
Covers damaged/         Covers damaged/         Covers restored and/or laminated/         Covers restored and/or laminated/         Cover title missing/         Cover title missing/         La titre de couverture manque         Coloured meps/         Coloured ink (i.e. other then blue or black)/         Coloured jates and/or illustrations/         Planches et/ou illustrations en couleur         Bound with other material/         Relié avec d'autres documents         Tight binding may cause shadows or distortion along interior margin/         La reliver serice peut causer de l'ombre ou de la distorsion le long de la marge intérieure         Blank leaves added during restorstion may appear within the text. Whenever possible, these have been omitted from filming/         Il se peut que certaines pages hlanches ajoutées lors d'une restauration apparesisent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.         Additional comments:/	Couvers oversioned and/or leminated/         Couvers restored and/or leminated/         Coloured lets and/or illustrations/         Planches et/ou illustrations en couleur         Bound with other material/         Tight binding	e itaan is film	ad at the reducti	ion ratio che	ecked belo	w/						
Covers damaged/         Covers restored and/or leminated/         Cover title missing/         Le titre de couverture manque         Coloured meps/         Coloured ink (i.e. other then blue or black)/         Encre de couleur (i.e. autre que bleue ou noire)         Pages détached/         Pages détachés         Coloured plates and/or illustrations/         Planches et/ou illustrations en couleur         Bound with other material/         Relié avec d'autres documents         Tight binding may cause shadows or distortion along interior margin/         La reliure servée poeut causer de l'ombre ou de la distorsion le long de la marge intérieure         Biank leaves added during restoration may appear within the text. Whenever possible, these heve been omitted from filming/         Its peut que certaines pages blanches ajoutés lors d'une restauration appareisent dans le texte, main, lorsque cela était possible, ces pages n'ont pas été filmées.         Masthead/       Générique (périodiques) de la livraison </td <td>Couvers of exception         Couvers of exception         Couvers restored and/or leminated/         Couvers rule mangue         Couvers rule mangue         Coloured meps/         Cortes géographiques en couleur         Coloured ink (i.e. other then blue or black)/         Encre de couleur (i.e. autre que bleue ou noire)         Coloured jetes and/or illustrations/         Planches et/ou illustrations en couleur         Bound with other material/         Relié avec d'autres documents         Tight binding may cause shadows or distortion along interior margin/         La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure         Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/         Il se peut que certaines pages blanches ajoutées fors d'une restauration appareissent dans le texte, mai</td> <td></td> <td></td> <td>aires:</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	Couvers of exception         Couvers of exception         Couvers restored and/or leminated/         Couvers rule mangue         Couvers rule mangue         Coloured meps/         Cortes géographiques en couleur         Coloured ink (i.e. other then blue or black)/         Encre de couleur (i.e. autre que bleue ou noire)         Coloured jetes and/or illustrations/         Planches et/ou illustrations en couleur         Bound with other material/         Relié avec d'autres documents         Tight binding may cause shadows or distortion along interior margin/         La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure         Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/         Il se peut que certaines pages blanches ajoutées fors d'une restauration appareissent dans le texte, mai			aires:								
Covers damaged/         Covers restored and/or leminated/         Cover title missing/         Le titre de couverture manque         Coloured meps/         Coloured meps/         Coloured ink (i.e. other then blue or black)/         Encre de couleur (i.e. autre que bleue ou noire)         Pages détachéds         Coloured plates and/or illustrations/         Planches et/ou illustrations en couleur         Bound with other material/         Relié avec d'autres documents         Tight binding may cause shadows or distortion along interior margin/         La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure         Blank leaves added during restoration may appear within the text. Whenever possible, these heve been omitted from filming/         Its peut que certaines pages blanches ajoutées lors d'une restauration appareisent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.         Distended       Caption of issue/	Couverture de couleur       Pages de couleur         Couverture endommagée       Pages de couleur         Couverture endommagée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages decolorées, tachetées ou pelliculées         Couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages décolorées, tachetées ou piquées         Coloured plates and/or illustrations/       Pages décolorées, tachetées         Coloured plates and/or illustrations/       Quality of print varies/         Planches et/ou illustrations en couleur       Quality of print varies/         Relié avec d'autres documents       Quality of print varies/         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/         La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure       Title on header taken from:/         Blank leaves added during restoration may appear within the text. Whenever possible, these heve been omitted from filming/       Title page of issue/         Page de titre de la livraison       Page de titre de la livraison	Additional	comments:/									
Covers damaged/         Covers damaged/         Covers restored and/or leminated/         Covers title missing/         Le titre de couverture manque         Coloured meps/         Coloured ink (i.e. other then blue or black)/         Coloured ink (i.e. other then blue or black)/         Encre de couleur (i.e. autre que bleue ou noire)         Coloured jates and/or illustrations/         Planches et/ou illustrations en couleur         Coloured plates and/or illustrations/         Planches et/ou illustrations en couleur         Bound with other material/         Relié avec d'autres documents         Tight binding may cause shadows or distortion along interior margin/         Le titre de long de la marge intérieure         Blank leaves added during restoration may appear         within the text. Whenever possible, these heve been omitted from filming/         It se peut que certaines pages blanches ajoutées         Its peut que certaines pages blanches ajoutées         Its peut qu	Couver ure de couleur       Pages de couleur         Couver ure endommagée       Pages de couleur         Couver ure restaurée c/ou pelliculée       Pages restored and/or laminated/         Couver ure restaurée et/ou pelliculée       Pages restored and/or laminated/         Couver ure restaurée et/ou pelliculée       Pages restored and/or laminated/         Couver title missing/       Pages discoloured, stained or foxed/         Le titre de couver ure manque       Pages décolorées, tachetées ou piquées         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured plates and/or illustrations/       Pages détachées         Planches et/ou illustrations en couleur       Quality of print varies/         Bound with other material/       Quality of print varies/         Planches et/ou illustrations en couleur       Continuous pagination/         Pagination continue       Includes index(es)/         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/         La reliure servée peut causer de l'ombre ou de la distorsion le long de la marge intérieure       Title on header taken from: /         Biank leaves added during restoration may appear within the text. Whenever possible, these here been omitted from filming/       Page de titre de la livraison         It							Génériqu	ue (périodiqu	ues) de la li	vraison	
Covers damaged/         Covers damaged/         Covers restored and/or leminated/         Covers restored and/or leminated/         Covers restored and/or leminated/         Coverture restaurée et/ou pelliculée         Cover title missing/         Le titre de couverture manque         Coloured meps/         Coloured meps/         Cartes géographiques en couleur         Coloured ink (i.e. other then blue or black)/         Encre de couleur (i.s. autre que bleue ou noire)         Coloured plates and/or illustrations/         Planches et/ou illustrations en couleur         Bound with other material/         Relié avec d'autres documents         Tight binding may cause shadows or distortion along interior margin/         La reliure servée peut causer de l'ombre ou de la distorsion le long de la marge intérieure         Blank leaves added during restoration may appear within the text. Whenever possible, these heve been omitted from filming/         Il se peut que certaines pages blanches ajoutées lorg d'une restauration appareissent dans le taxte, mais, lorsque cela était possible, ces pages n'ont	Couverture de couleur       Pages de couleur         Couverture endommagée       Pages damaged/         Couverture endommagée       Pages endommagées         Couverture endommagée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages décolorées, tachetées ou piquées         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured plates and/or illustrations/       Pages détachées         Coloured plates and/or illustrations en couleur       Oualité inégale de l'impression         Bound with other material/       Continuous pagination/         Relié avec d'autres documents       Comprend un (des) index         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/         Blank leaves added during restoration may appear within the text. Whenever possible, these here been omitted from filming/       Title page of issue/         It se page de citaines pages blanches ajoutées lorg dure restaurati	has are un						Masthea	d/			
Covers damaged/         Covers damaged/         Covers restored and/or laminated/         Covers title missing/         Le titre de couverture manque         Coloured meps/         Coloured meps/         Coloured ink (i.e. other then blue or black)//         Encre de couleur (i.e. autre que bleue ou noire)         Coloured plates and/or illustrations/         Planches et/ou illustrations en couleur         Bound with other material/         Relié avec d'autres documents         Tight binding may cause shadows or distortion along interior margin/         La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure         Blank leaves added during restoration may appear within the text. Whenever possible, these heve been omitted from filming/         H se peut que certaines pages blanches ajoutées lorg d'une restauration appereistent dans le texte,         Diang interior margin/         La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure         Blank leaves ad	Couverture de couleur       Pages de couleur         Couverture de couleur       Pages de couleur         Couverture endommagée       Pages endommagées         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages detached/         Coloured ink (i.e. other then blue or black!)/       Pages détachées         Coloured plates and/or illustrations/       Pages détachées         Planches et/ou illustrations en couleur       Qualité inégale de l'impression         Bound with other material/       Continuous pagination/         Relié avec d'autres documents       Continuous pagination/         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/         La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure       Title on header taken from:/         Blank leaves added during restoration may appear within the text. Whenever possible, these heve been omitted from filming/       Page de titre de la livraison         It se peut que certai		The second se	isible, ces pa	ges n'ont			litre de	depart de la	livraison		
Couverture endommagée       Peges damaged/         Covers damaged/       Pages endommagées         Covers restored and/or leminated/       Pages endommagées         Covers restored and/or leminated/       Pages restored and/or laminated/         Covers restored and/or leminated/       Pages restored and/or laminated/         Covers restored and/or leminated/       Pages restored and/or laminated/         Covers title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages détachées         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured plates and/or illustrations/       Pages détachées         Planches et/ou illustrations en couleur       Quality of print varies/         Planches et/ou illustrations en couleur       Quality of print varies/         Bound with other material/       Continuous pagination/         Relié avec d'autres documents       Continuous pagination/         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/         Comprend un (des) index       Tite on header taken from:/         Le titre de l'en-tite provient:       Page de titre de la livraison	Couverture de couleur       Pages de couleur         Couverture de couleur       Pages de couleur         Couverture endommagée       Pages anaged/         Couverture endommagée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages decolored, stained or foxed/         Couverture restaurée et/ou pelliculée       Pages decolorées, tachetées ou pelliculées         Coloured meps/       Pages decolorées, tachetées ou piquées         Coloured ink (i.e. other then blue or black)/       Pages décolorées, tachetées ou piquées         Coloured ink (i.e. other then blue or black)/       Showthrough/         Encre de couleur (i.e. autre que bleue ou noire)       Quality of print varies/         Coloured plates and/or illustrations/       Qualité inégale de l'impression         Bound with other material/       Continuous pagination/         Relië avec d'autres documents       Includes index(es)/         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/         Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/       Title page of issue/         Page de titre de l'en-tête provient:       Page de titre de la livraison	lors d'une	restauration app	pareissent da	ins le texte			•				
Couverture endommagée       Pages damaged/         Covers damaged/       Pages endommagées         Covers restored and/or leminated/       Pages restored and/or laminated/         Cover title missing/       Pages restored and/or laminated/         Le titre de couverture manque       Pages discoloured, stained or foxed/         Coloured meps/       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages décolorées, tachetées ou piquées         Coloured ink (i.e. other then blue or black)//       Pages détachées         Coloured plates and/or illustrations/       Pages detached/         Planches et/ou illustrations en couleur       Quality of print varies/         Bound with other material/       Continuous pagination/         Relié avec d'autres documents       Includes index(es)/         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/         La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure       Includes index(es)/         Blank leaves added during restoration may appear within the text. Whenever possible, these heve       Title page of issue/	Course dormaged       Pages de couleur         Couverture de couleur       Pages de couleur         Couverture endommagée       Pages endommagées         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages descoloured, stained or foxed/         Le titre de couverture manque       Pages descoloured, stained or foxed/         Coloured meps/       Pages descolorées, tachetées ou piquées         Coloured meps/       Pages detached/         Coloured plates and/or illustrations/       Pages détachées         Coloured plates and/or illustrations en couleur       Qualité inégale de l'impression         Bound with other material/       Continuous pagination/         Relié avec d'autres documents       Comprend un (des) index         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/         La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure       Title on header taken from:/         Blank leaves added during restoration may appear within the text. Whenever possible, these heve       Title page of issue/	Il se peut d	que certaines pag	ges blanches								
Couverture endommagée       Peges damaged/         Covers damaged/       Peges endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/         Coverture restaurée et/ou pelliculée       Peges restored and/or laminated/         Coverture restaurée et/ou pelliculée       Peges restored and/or laminated/         Coverture restaurée et/ou pelliculée       Peges restored and/or laminated/         Cover title missing/       Peges discoloured, stained or foxed/         Le titre de couverture manque       Peges décolorées, tachetées ou piquées         Coloured meps/       Pages détachéd/         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured plates and/or illustrations/       Planches et/ou illustrations/         Planches et/ou illustrations en couleur       Quality of print varies/         Bound with other material/       Continuous pagination/         Relié avec d'autres documents       Includes index(es)/         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/         La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure       Title on header taken from: / Le titre de l'en-tête provient:         Blank leaves added during restoration may appeer       Entre de l'en-tête provient:	Couverture de couleur       Pages de couleur         Couverture de couleur       Pages de couleur         Couverture endommagée       Pages endommagées         Couverture endommagée       Pages endommagées         Couverture restaurée et/ou pelliculée       Pages discoloured, stained / Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées         Coloured meps/ Coloured meps/ Coloured ink (i.e. other then blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)       Pages détachées         Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur       Qualitý of print varies/ Qualitý inégale de l'impression         Bound with other material/ Relië avec d'autres documents       Continuous pagination/ Pagination continue         Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure       Includes index(es)/ Comprend un (des) index Title on header taken from:/ Le titre de l'en-tête provient:         Blank leaves added during restoration may appear       Staves									raison		
Couverture endommagée       Peges damaged/         Covers damaged/       Peges endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/         Cover tite missing/       Peges restored and/or laminated/         Cover tite missing/       Peges restored and/or laminated/         Le titre de couverture manque       Peges restored and/or laminated/         Cover tite missing/       Peges discoloured, stained or foxed/         Le titre de couverture manque       Peges décolorées, tachetées ou piquées         Coloured meps/       Pages décolorées, tachetées ou piquées         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured plates and/or illustrations/       Planches et/ou illustrations en couleur         Bound with other material/       Continuous pagination/         Relié avec d'autres documents       Comprend un (des) index         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/         La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure       Title on header taken from:/	Couverture de couleur       Pages de couleur         Couverture de couleur       Peges damaged/         Couverture endommagée       Peges damaged/         Couverture endommagée       Peges damaged/         Couverture endommagée       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Peges restored and/or laminated/         Covers restored and/or leminated/       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Peges discoloured, stained or foxed/         Cover title missing/       Le titre de couverture manque       Peges décolorées, tachetées ou piquées         Coloured meps/       Cartes géographiques en couleur       Peges détached/         Coloured ink (i.e. other then blue or black)/       Peges détachées       Showthrough/         Coloured plates and/or illustrations/       Planches et/ou illustrations en couleur       Qualité inégale de l'impression         Bound with other material/       Continuous pagination/       Pagination continue         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/       Comprend un (des) index         Title on header taken from:/       Le titre de l'en-tête provient:       Entre de l'en-tête provient:					r		Title ner	no of issue/			
Couverture de courch       Peges damaged/         Covers damaged/       Peges damaged/         Couverture endommagée       Peges nettored and/or laminated/         Covers restored and/or leminated/       Peges restored and/or laminated/         Cover title missing/       Peges restored and/or laminated/         Cover title missing/       Peges discoloured, stained or foxed/         Le titre de couverture manque       Pages discoloured, stained or foxed/         Coloured meps/       Pages detached/         Coloured ink (i.e. other then blue or black)/       Pages detached/         Encre de couleur (i.e. autre que bleue ou noire)       Showthrough/         Coloured plates and/or illustrations/       Quality of print varies/         Planches et/ou illustrations en couleur       Quality of print varies/         Bound with other material/       Continuous pagination/         Pagination continue       Includes index(es)/         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/         La reliure serrée peut causer de l'ombre ou de la       Includes index(es)/	Couverture de couleur       Pages de couleur         Couverture de couleur       Pages de couleur         Couverture endommagée       Pages de couleur         Couverture endommagée       Pages de couleur         Couverture endommagée       Pages de couleur         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages descoloured, stained or foxed/         Cover title missing/       Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Coloured meps/       Pages détachées         Coloured ink (i.e. other then blue or black)/       Showthrough/         Encre de couleur (i.e. autre que bleue ou noire)       Showthrough/         Coloured plates and/or illustrations/       Qualité inégale de l'impression         Bound with other material/       Continuous pagination/         Relié avec d'autres documents       Continuous pagination/         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/         La reliure serrée peut causer de l'ombre ou de la       Comprend un (des) index							Le titre d	de l'en-tête p	rovient:		
Covers damaged/       Peges damaged/         Covers restored and/or leminated/       Peges restored and/or laminated/         Covers restored and/or leminated/       Peges restored and/or laminated/         Cover title missing/       Peges restored and/or laminated/         Cover title missing/       Peges restored and/or laminated/         Le titre de couverture manque       Peges discoloured, stained or foxed/         Colured meps/       Peges detached/         Cartes géographiques en couleur       Peges detached/         Coloured ink (i.e. other then blue or black)/       Peges detached/         Encre de couleur (i.e. autre que bleue ou noire)       Pages detachées         Coloured plates and/or illustrations/       Quality of print varies/         Planches et/ou illustrations en couleur       Continuous pagination/         Bound with other material/       Continuous pagination/         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/	Couverture de couleur       Pages de couleur         Couverture de couleur       Peges damaged/         Couverture endommagée       Peges damaged/         Covers restored and/or leminated/       Peges restored and/or laminated/         Coverture restaurée et/ou pelliculée       Peges restored and/or laminated/         Cover title missing/       Peges discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou pelliculées         Coloured meps/       Pages décolorées, tachetées ou piquées         Coloured ink (i.e. other then blue or black)/       Pages décachées         Coloured ink (i.e. other then blue or black)/       Showthrough/         Transparence       Quality of print varies/         Coloured plates and/or illustrations/       Qualité inégale de l'impression         Bound with other material/       Continuous pagination/         Relié avec d'autres documents       Includes index(es)/         Tight binding may cause shadows or distortion along interior margin/       Includes index(es)/											
Couverture de couldi.       Peges damaged/         Couverture endommagée       Peges damaged/         Couverture endommagée       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Peges restored and/or laminated/         Cover title missing/       Peges discoloured, stained or foxed/         Le titre de couverture manque       Peges décolorées, tachetées ou piquées         Coloured meps/       Pages décolorées, tachetées ou piquées         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured plates and/or illustrations/       Planches et/ou illustrations en couleur         Bound with other material/       Quality of print varies/         Bound with other material/       Continuous pagination/         Pagination continue       Includes index(es)/	Couverture de couleur       Pages de couleur         Couverture de couleur       Pages de couleur         Covers damaged/       Pages de couleur         Couverture endommagée       Pages endommagées         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages descoloured, stained or foxed/         Couverture restaurée et/ou pelliculée       Pages descoloured, stained or foxed/         Couverture manque       Pages descoloured, stained or foxed/         Coloured meps/       Pages detached/         Coloured ink (i.e. other then blue or black)/       Pages detachées         Coloured ink (i.e. other then blue or black)/       Pages detachées         Coloured plates and/or illustrations/       Quality of print varies/         Planches et/ou illustrations en couleur       Qualité inégale de l'impression         Bound with other material/       Continuous pagination/         Relié avec d'autres documents       Includes index(es)/			er de l'ombre	e ou de la							
Couverture endommagée       Pages damaged/         Couverture endommagée       Pages endommagées         Couverture endommagée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou pelliculées         Coloured meps/       Pages détached/         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured plates and/or illustrations/       Quality of print varies/         Planches et/ou illustrations en couleur       Qualité inégale de l'impression         Bound with other material/       Continuous pagination/         Pagination continue       Pagination continue	Couverture de couleur       Pages de couleur         Couverture de couleur       Pages de couleur         Couverture endommagée       Pages de couleur         Covers restored and/or leminated/       Pages endommagées         Coverture restaurée et/ou pelliculée       Pages discoloured, stained or foxed/         Cover title missing/       Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Cartes géographiques en couleur       Pages décolorées, tachetées ou piquées         Coloured ink (i.e. other then blue or black)/       Pages décolorées       Showthrough/         Coloured plates and/or illustrations/       Quality of print varies/       Qualité inégale de l'impression         Bound with other material/       Continuous pagination/       Pagination continue	1 -		INCOMS OF GI	stortion					ndex		
Covers damaged/       Peges damaged/         Covers restored and/or leminated/       Peges restored and/or laminated/         Cover setored and/or leminated/       Peges restored and/or laminated/         Cover title missing/       Peges restored and/or laminated/         Le titre de couverture manque       Peges discoloured, stained or foxed/         Coloured meps/       Peges detached/         Coloured ink (i.e. other then blue or black)/       Peges detachées         Coloured plates and/or illustrations/       Planches et/ou illustrations en couleur         Bound with other material/       Continuous pagination/	Couverture de couleur       Pages de couleur         Couverture de couleur       Pages de couleur         Couverture endommagée       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages détached/         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured plates and/or illustrations/       Quality of print varies/         Planches et/ou illustrations en couleur       Qualité inégale de l'impression         Bound with other material/       Continuous pagination/							Includes	index (ca)/			
Couverture de codect         Covers damaged/         Couverture endommagée         Covers restored and/or leminated/         Couverture restaurée et/ou pelliculée         Cover title missing/         Le titre de couverture manque         Coloured meps/         Coloured ink (i.e. other then blue or black)/         Encre de couleur (i.e. autre que bleue ou noire)         Coloured plates and/or illustrations/         Planches et/ou illustrations en couleur	Colument de couleur       Pages de couleur         Couverture de couleur       Pages de couleur         Couverture endommagée       Pages de couleur         Couverture endommagée       Pages endommagées         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages détachées         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured plates and/or illustrations/       Planches et/ou illustrations en couleur         Coloured plates and/or illustrations en couleur       Qualité inégale de l'impression	Relié avec	d'autres docume	ints				Paginatio	on continue			
Covers damaged/       Peges damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Peges restored and/or laminated/         Cover title missing/       Peges discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages détached/         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured ink (i.e. other then blue or black)/       Showthrough/         Transparence       Quality of print varies/	Couverture de couleur       Pages de couleur         Couverture de couleur       Pages de couleur         Couverture endommagée       Pages de couleur         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages détachées         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured ink (i.e. autre que bleue ou noire)       Manue bleur varies/         Coloured plates and/or illustrations/       Quality of print varies/	] Bound wit	h other material	1				Continue	ous paginatio	m/		
Covers damaged/       Peges damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Peges restored and/or laminated/         Cover title missing/       Peges discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages détached/         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured ink (i.e. other then blue or black)/       Showthrough/         Transparence       Quality of print varies/	Couverture de couleur       Pages de couleur         Couverture de couleur       Pages de couleur         Couverture endommagée       Pages de couleur         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages détachées         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured ink (i.e. autre que bleue ou noire)       Manue bleur varies/         Coloured plates and/or illustrations/       Quality of print varies/	I Planches et		en couledi								
Covers damaged/       Peges damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Peges restored and/or laminated/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages detached/         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured ink (i.e. autre que bleue ou noire)       Showthrough/	Couverture de couleur       Pages de couleur         Couverture de couleur       Pages de couleur         Couverture endommagée       Pages damaged/         Couverture endommagée       Pages endommagées         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Cartes géographiques en couleur         Coloured ink (i.e. other then blue or black)/       Pages détachées         Coloured ink (i.e. autre que bleue ou noire)       Showthrough/							•				
Covers damaged/ Couverture endommagée       Pages damaged/ Pages endommagées         Covers restored and/or leminated/ Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/ Pages restaurées et/ou pelliculées         Cover title missing/ Le titre de couverture manque       Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées         Coloured meps/ Cartes géographiques en couleur       Pages detached/ Pages détachées         Coloured ink (i.e. other then blue or black)/       Showthrough/	Couverture de couleur   Couverture de couleur   Covers damaged/   Couverture endommagée   Covers restored and/or leminated/   Couverture restaurée et/ou pelliculée   Cover title missing/   Le titre de couverture manque   Coloured meps/   Coloured meps/   Coloured ink (i.e. other then blue or black)/							Quality	of print warie			
Covers damaged/ Couverture endommagée       Peges damaged/ Pages endommagées         Covers restored and/or leminated/ Couverture restaurée et/ou pelliculée       Peges restored and/or laminated/ Pages restaurées et/ou pelliculées         Cover title missing/ Le titre de couverture manque       Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées         Coloured meps/ Cartes géographiques en couleur       Pages detached/ Pages détachées         Coloured ink (i.e. other then blue or black)/       Showthrough/	Couverture de couleur   Couverture de couleur   Covers damaged/   Couverture endommagée   Covers restored and/or leminated/   Couverture restaurée et/ou pelliculée   Cover title missing/   Le titre de couverture manque   Coloured meps/   Coloured meps/   Coloured ink (i.e. other then blue or black)/	Encre de c	ouleur (i.e. autre	que bleue a	ou noire)		Ľ	Transpar	ence			
Covers damaged/       Peges damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages detached/	Couverture de couleur       Pages de couleur         Covers damaged/       Pages damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages discoloured, stained or foxed/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages detached/								-			
Covers damaged/       Peges damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées         Coloured meps/       Pages detached/	Couverture de couleur       Pages de couleur         Covers damaged/       Pages damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages discoloured, stained or foxed/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages detached/											
Covers damaged/       Peges damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Peges restored and/or laminated/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées	Couverture de couleur       Pages de couleur         Couverture de couleur       Pages de couleur         Covers damaged/       Pages damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Pages restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restored and/or laminated/         Cover title missing/       Pages discoloured, stained or foxed/         Le titre de couverture manque       Pages décolorées, tachetées ou piquées			uleur								
Covers damaged/       Peges damaged/         Covers restored and/or leminated/       Peges restored and/or laminated/         Covers title missing/       Peges discoloured, stained or foxed/	Couverture de couleur       Pages de couleur         Covers damaged/       Peges damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages discoloured, stained or foxed/         Cover title missing/       Pages discoloured, stained or foxed/	7 Coloured -						Pages det	tached/			
Covers damaged/       Peges damaged/         Covers restored and/or leminated/       Peges restored and/or laminated/         Covers title missing/       Peges discoloured, stained or foxed/	Couverture de couleur       Pages de couleur         Covers damaged/       Peges damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages discoloured, stained or foxed/         Cover title missing/       Pages discoloured, stained or foxed/	Le titre de	couverture mano	que			ليسم	rages dec	solorees, tacr	ierces ou p	idneez	
Covers damaged/       Peges damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restaurées et/ou pelliculées	Couverture de couleur       Pages de couleur         Covers damaged/       Peges damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/         Couverture restaurée et/ou pelliculée       Pages restaurées et/ou pelliculées											
Covers damaged/ Couverture endommagée Covers restored and/or leminated/	Couverture de couleur       Pages de couleur         Covers damaged/       Peges damaged/         Couverture endommagée       Pages endommagées         Covers restored and/or leminated/       Peges restored and/or laminated/							•				
Covers damaged/ Couverture endommagée Pages endommagées	Couverture de couleur       Pages de couleur         Covers damaged/       Peges damaged/         Couverture endommagée       Pages endommagées							Pages rest	taurées et/ou	pelliculée:	1	
Covers damaged/	Covers damaged/	Covers rest	ored and/or lemi	inated/				Peges rest	tored and/or	laminated	1	
Covers damaged/	Couverture de couleur  Covers damaged/  Pages damaged/	Couverture	endommagee					rages end	Johnnayees			
	Couverture de couleur Pages de couleur		•					-	-			
Couverture de couleur												
	Coloured covers/											

The copy filmed here has been reproduced thanks to the generosity of:

University of Toronto Archives

The images appearing here are the best quality possible considering the condition and legibility of the original copy and in keeping with the filming contract specifications.

Originei copies in printed peper covers ere filmed beginning with the front cover end ending on the lest pege with e printed or lilustrated impression, or the beck cover when eppropriate. All other originel copies ere filmed beginning on the first page with e printed or illustrated impression, and ending on the lest pege with e printed or illustrated impression.

The last recorded frame on each microfiche shall contain the symbol  $\longrightarrow$  (meaning "CON-TINUED"), or the symbol  $\nabla$  (meaning "END"), whichever epplies.

Maps, plates, cherts, etc., may be filmed at different reduction ratios. Those too large to be entirely included in one exposure are filmed beginning in the upper left hand corner, left to right end top to bottom, as many frames as required. The following diegrams illustrate the method:

1 2 3
-------

1	2
4	5

L'exemplaire filmé fut reproduit grâce à la générosité de:

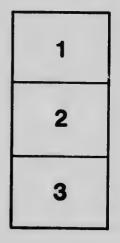
University of Toronto Archives

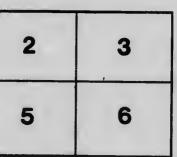
Les Images sulvantes ont été reproduites evec le plus grand soin, compte tenu de la condition et de le netteté de l'exempiaire filmé, et en conformité avec les conditions du contret de filmage.

Les exemplaires originaux dont la couverture en papier est imprimée sont filmés en commençant per le premier plet et en terminent soit par la dernière pege qui comporte une empreinte d'impression ou d'illustretion, soit par le second plat, seion le cas. Tous les autres exempleires origineux sont filmés en commençant par le première page qui comporte une empreinte d'Impression ou d'Illustration et en terminant par le dernière page qui comporte une teile empreinte.

Un des symboles sulvents apperaître sur ie dernière image de chaque microfiche, selon ie cas: ie symbole → signifie "A SUIVRE", ie symbole ♥ signifie "FIN".

Les certes, plenches, tableeux, etc., peuvent être filmés à des teux de réduction différents. Lorsque le document est trop grand pour être reprodult en un seui cliché, il est filmé à partir de l'angle supérieur gauche, de gauche à droite, et de haut en bas, en prenent le nombre d'imeges nécessaire. Les diegrammes sulvants lilustrent le méthode.





# University of Toronto.

Lat A Gutin

## PAPERS

#### CHEMICAL LABORATORY.

No. 20.—Chemical and Physical Reactions.

Reprinted from on Journal of the Ontailor Educational Association, April, 1902.

#### TORONTO, 1902.

STATE TARE



### CHEMICAL AND PHYSICAL REACTIONS.

#### BY W. LASH MILLER, PH.D., F.R.S.C., TORONTO.

A Paper Read Before the Educational Association, Wednesday, April 2nd, 1992.

In the last few years it has become quite the fashion for physicists and chemists to write books on the philosophy of their respective sciences, and last year the climax was reached when

of the best known of the German Professors of Chemistry, in blic, having been granted a year's holiday by the University borities, spent it in preparing and delivering a course of leeus on philosophy.\* My friend, Dr. J. J. Mackenzie, who was present at some of the lectures, informs me that they were delivered in the largest lecture-room in the University, and were regularly attended by an audience of between three and four hundred; so that, whether the philosophy was good or bad, we may be sure that the lectures were interesting.

There are two matters, rather obvious perhaps, but very important, on which all these amatenr philosophers agree. The first is: That the nomenclature, the theories, and the general trend of thought common among scientific men at any time, depend not only on the facts of the science which are known at that time, but also, and in a much greater degree, on the order in which these facts have been discovered and interpreted. The theories put forward to explain the phenomena first studied are retained, and patched, and added to, and forced to explain the new facts as they are brought to light.

We are all such conservatives at heart—whatever we may call ourselves for political purposes—that the mere fact that a theory is an old one, and has been taught us when we were students, seems to be an argument in its favor; whereas, in reality it only proves that the theory in question was invented in the old days, when a great many facts now familiar had not yet been discovered. And the consequence of this conservatism is that when the time has come for the old theory to step aside—when in the struggle f r existence it has been defeated by a younger rival—

Published as "Vorlesungen neber Naturphilosophie, von W. Ostwald." Leipsie: Veit & Comp. 1902. there are always men to be found who will range themselves resointely on the side of the old against the new—men who geruinely believe in the theory in which they have been brought up, and who may be relied upon to advance and defend any absurdity, if only it afford a chance of escape from the logic of their opponents.

An excellent example is afforded by the contest between the Phlogiston theory and the present theory of combustion, which took place at the end of the eighteenth century. In spite of the advantages of the modern view, obvious enough now, the Phlogiston theory died hard. Some of its adherents pooh-poohed all arguments based on the use of the balance, on the ground that this was a "physical" instrument, and onght not to be bro  $\uparrow$ , into a purely chemical controversy. Others endowed Phlogiston, with negative gravity, others again identified it with hydrogen—anything but give it np. Priestly, the discoverer of oxygen, remained stendfast to the last: a Phlogistonist he was born, and a Phlogistonist he died.

The second point made by our philosophers is: That the order of discovery, on which so much depends, though settled in some cases by chance, and in many cases by pecuniary and economic conditions, in general follows this law, namely, that the most striking, the most wonderful, phenomena are taken up first; the commonplace and the uninteresting have to wait.

Of all chemical phenomena the most striking are certainly those of combustion with the evolution of flames, light and heat; and, accordingly, we find that the first chemical theory was the Phlogiston theory, or Flame theory. Its downfall was brought about by the study of comparatively obscure reactions of mercury and lead.

After combustion, the reaction between acids and bases has attracted the attention of chemists perhaps more than any other. In this jar I have a mixture of sulphuric acid and water, some litmus, a stirrer, and the bulb of a thermometer : in the burcte is ammonia. As the aumonia runs into the jar its smell and taste and the sharp taste of the acid disappear; the thermometer rises, the liquid expands (two pints do not make a quart when one is ammonia and the other sulphuric acid): in short, a "chemical reaction" is taking place. Science Science of the litmus changes to blue, the smell of ammonia is noticeable, and the thermometer ceases to rise, although ammonia is still flowing into the cylinder—the reaction is over. The more this reaction was studied the more wonders were discovered. We began with ammenia gas and water, and (liquid) sulphuric acid and water; if water be removed from the contents of the cylinder a solid will remain. Measurement of the quantities of acids and alkalies which react together led to the law of combination in reciprocal proportions; the law of combination in multiple proportions soon followed, to explain which the schoolmaster of Manchester set up his Atomic theory, one hundred years ago—an extraordinary theory, based on extraordinary facts.

Originally invented to explain the law of multiple proportions, the Atomic theory soon became the fundamental doctrine of  $\epsilon_{11}$  try. The highest aim of chemistry was to become the "mc\_m ics of the atoms." In the cylinder we saw the bubbling hiquid, the rising thermometer, the change of color. We are invited to believe that what was "really." there was: a whirl of atoms and molecules, attracting and repelling one another, rushing past one another, colliding, uniting together. A little universe in the cylinder: an astronomical system on the small scale.

You have read, no doubt—perhaps in some Commentary on the Book of Joshua—of the tremendous quantity of heat that would be generated if this earth should suddenly stand still: or, worse, should collide with some other planet. The heat of combustion of dozens of earths of coal would be nothing to it. When the ammonia planet coldes with the acid planet in the astronomical system in the cylinder, a similar quantity of heat must obviously be generated; it is only be use these planets are as small as the others are large, that we have escaped with cur lives !

Thomsen, of Sweden, and Berthelot, of Paris, were the first to call attention to this consequence of the "mechanics of the atoms." "Every genuine chemical reaction must be accompanied by evolution of heat "—using words borrowed from the science of mechanics, Berthelot baptized this principle the "Law of Maximum Work."

Now, Thomsen was a Northern chemist: but Berthelot lives in Paris, were it is execrably hot in the summer time, and every time he put a bottle of champagne on ice he must have been reminded that there are reactions which are eccompanied by a very considerable—and a very grateful and comforting—*absorption* of heat. Lest it should escape his notice, this fact was repeatedly pointed out to him by others, some of whom were perhaps a little too much inclined to jeer at his law of maximum work. But Berthelot had a reply. He silenced all criticism by distinguishing between " chemical " and " physical " reactions. Such reactions us the change of ice into water, of water into steam, and of salt and water into brine, do not come into the province of the law of combination in multiple proportions, and they are in flat opposition to the law of maximum work : so Berthelot read them out of the party, and denied their right to be called chemical.

When we speak of this celebrated chemist "silencing all opposition" to his law of maximum work, these words may be taken, I am sorry to say, in a very literal sense. Besides being a chemist, this remarkable man was a politicism, and has occupied the position not only of head of the Department of Education, but of Minister of Foreign Affairs of the French Republic. His word was law is all that concerned appointments in chemistry in the l'miversity of France, and more than one French chemist has found that opposition to the scientific views of the powerful Minister meant exile from Paris. For them, the law of maximum work read " Maximum Work and Minimum Pay " in a distant part of the provinces, far from the bonlevards of Paris where we have pictured the Head Chemist of France keeping himself comfortable during the hot weather by the help of a heat-absorbing-and therefore waction. nou-chemi

Under somewhat similar circumstances Galileo recanted, consoling himself with the reflection that his words would not affect the motion of the earth. But these men were teachers; a single perfunctory recantation would not serve in their case; they were called upon to *teach* what they believed to be false. If they had consented the motion of the world would have been perceptibly retarded.

Leaving the chemists and returning to chemistry, Berthelot's views met with fair success. Everywhere we find the majority agreed that to boil water is not a "chemical" process, neither is it to dissolve sugar in one's tea. Ice and water, water and steam, are "the same thing," and in the brine both salt and water are present "unchanged." Can one not see the water *t* and *taste* the salt?

The physicists, too, were satisfied. The reactions ejected from the "official tabernacle" of chemistry found a good reception. Regnault, the eelebrated experimentalist had made an exhaustive study of the conditions under which water, ice, and steam may be converted one into the other, and finally Chausius perfected the theory of these reactions. Rejected by the chemists and adopted hy the physicists, surely these reactions have a good right to be called "physical."

Clausins' theory was a non-chemical theory, there were no atoms in it; and, still more characteristic, it involved the use of the cal-At that time the calculus was a distinctive tool of the culus physicist, just as previous to Lavoisier the balance was: and the sign  $d\mathbf{x}$  was as characteristic of a work on physics as  $H_2\theta$  is of one on chemistry. How much the times have changed can be seen from this lantern-slide. This change came about in a very natural Some level-headed manufacturers in place of setting manner. their chemists at work discovering ner compounds, which might or might not prove serviceable to them ... en discovere t taem instead to find the best methods of making produc. dready known, for which there was already a m rket. and thus a new problem arose in chemistry; to be solv -1 only by studying the influences that modify the nature and quantities of the products of chemical reactions, and Genates at which they take place : -for time is money in a chemica. ... tory as well as elsewhere.

This was the very problem that Regnault and Clausius had solved for the change of water into steam.

One of the most famous of the early experimenters in the new direction, was a chemist who studied the behavior of a great many substances at very high temperature; his faverite piece of apparatus was a white-hot platimum tube. This man went by the appropriate name of Deville. His most important discovery was, that many substances, water for instance, which are readily formed from their elements at ordinary temperatures, are decomposed into their elements again at a white heat. That, in fact, the reaction  $211 + 2O_z = H_zO$  is a "reversible" reaction in the same sense that the reaction " water = steam " is reversible; the one substance turns into the other, or the other into the one, depending on the temperature.

This discovery was a staggerer to the law of maximum work. When water is formed from its elements heat is given out; when it is decomposed heat is absorbed. If both phenomena were to be regarded as "chemical" reactions the law had to be repeated.

N

I shall not go into details as to the determined attempts that were made to uphold the majesty of this particular law: the last struggles of the phlogistonists a hundred years ago were not

\* Photograph of a page of van Laar's "Mathematische Chemie."

more ingenious and persistent. But the new facts brought to light in the eourse of the argument have gradually made it clear to every one that the reactions studied by Deville are not isolated, exceptional cases; but that, under suitable circumstances many of the best known "genuine chemical" reactions are as capable of taking place in either direction as are the physical reactions: Water =ice; water=steam; water+salt=brine.

The factors that determine the direction of the reaction—temperature, pressure, concentration—are the same that affect the physical reactions just enumerated; and lastly, while the theory of Clausius has proved eapable of predicting the direction and the yield of particular reactions under given circumstances, the Atomic theory cannot even "explain" the formulas and equations by which this result is accomplished. This seems to me a very striking eireumstance; every one who has used a "key" knows how easy it is in general to solve a problem when the answer is supplied.

And so, with heavy hearts, perhaps, and some of them later than others, the chemists took to buying Clausius' works and then books on the ealeulus, as a preliminary to understanding him; a bitter dose for those among them who had all their lives "thrown physics to the dogs," and whose higher mathematics were limited to the expression D— x. But, needs must! and now they are writing books on the same lines themselves. You remember the lantern slide?

Naturally enough an "anti-atom" party has arisen. "The mechanies of the atoms raised a barrier where none should exist," they say, "A la lanterne with the mechanies of the atoms!" Of course, it is possible to go too far in this direction also, and perhaps the Germans need to be reminded of their own proverbs: "When emptying the bath don't throw ont the baby," and "The seum is at the top, and the dregs at the bottom, but the beer is in the middle." The past history of the science however encourages us to hope that if there is any baby at all, or any beer, the chemists will succeed in finding them.

I have endeavored to give a short account of the history of the distinction between chemical and physical renetions. There was thought to be a difference of kind, it is now known to be one of degree only.

At the close of the paper an experiment\* was shown, illustrating the reversibility of the reaction,

#### $2SbCl_3 + 3H_2S = Sb_2S_3 + 6HCl.$

An antimony solution was prepared by dissolving 2 grammes of tartar-emetic in 20 ce. of hydrochloric acid sp. gr. 1.148, and diluting with 80 cc. of water.

(a) Passed a little H <sub>2</sub> S into 5 cc. antimony solution	-	>
(b) Added 15 cc. hydrochloric aeid (sp. gr. 1.148) -	-	<
(c) Added 5 ec. antimony solution	-	>
(d) Heated over a Bunsen burner	-	<
(e) Cooled again in a dish of water	•	>
(f) Added 10 cc. hydrochloric acid		<
(g) Saturated with H <sub>2</sub> S under 4 atmospheres pressu		>
(h) Reduced the pressure to 50 mm. (by a filter pum	թ) –	<

Note.—The arrows indicate the direction of the reaction; ..., meaning precipitation of  $Sb_{9}S_{3}$ , and <\_ formation of antimony chloride from the sulphide and hydrochloric acid.

• W. Lash Miller and F. B. Kenrick, Lecture Experiments, Reversible Chemica Reactions. Jour. Amer. Chem. Soc. xxii, 291 (1900).



