Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Higher level
Paper 1

Thursday 11 May 2017 (afternoon)

1 hour

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is **[40 marks]**.

2217 – 6113

17 pages

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The Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** 1.01			Atomic number **Element** Relative atomic mass														2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.90
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.96	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
6	55 **Cs** 132.91	56 **Ba** 137.33	57† **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** (226)	89‡ **Ac** (227)	104 **Rf** (267)	105 **Db** (268)	106 **Sg** (269)	107 **Bh** (270)	108 **Hs** (269)	109 **Mt** (278)	110 **Ds** (281)	111 **Rg** (281)	112 **Cn** (285)	113 **Unt** (286)	114 **Uug** (289)	115 **Uup** (288)	116 **Uuh** (293)	117 **Uus** (294)	118 **Uuo** (294)

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97

‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

1. What is the sum of the coefficients when the equation is balanced with whole numbers?

$$\_\_C_8H_{18}(g) + \_\_O_2(g) \rightarrow \_\_CO(g) + \_\_H_2O(l)$$

A. 26.5

B. 30

C. 53

D. 61

2. What is the maximum volume, in dm^3, of $CO_2(g)$ produced when 1.00 g of $CaCO_3(s)$ reacts with 20.0 cm^3 of 2.00 $mol\,dm^{-3}$ $HCl(aq)$?

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Molar volume of gas = 22.7 $dm^3\,mol^{-1}$; $M_r(CaCO_3) = 100.00$

A. $\frac{1}{2} \times \frac{20.0 \times 2.00}{1000} \times 22.7$

B. $\frac{20.0 \times 2.00}{1000} \times 22.7$

C. $\frac{1.00}{100.00} \times 22.7$

D. $\frac{1.00}{100.00} \times 2 \times 22.7$

3. Which factors affect the molar volume of an ideal gas?

I. Pressure
II. Temperature
III. Empirical formula

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

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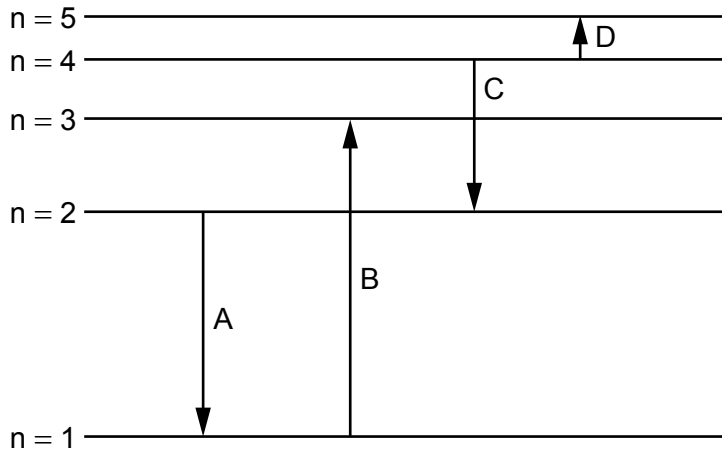
4. Which electron transition emits radiation of the longest wavelength?



5. X, Y and Z represent the successive elements, Ne, Na and Mg, but not necessarily in that order.

	First ionization energy / kJ mol^{-1}
X	2081
Y	496
Z	738

What is the order of increasing atomic number?

A. X < Y < Z

B. X < Z < Y

C. Y < Z < X

D. Y < X < Z

6. Which property increases down Group 1, the alkali metals?

A. Atomic radius

B. Electronegativity

C. First ionization energy

D. Melting point

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7. Which element is a lanthanide?

A. Hf

B. Tb

C. U

D. Y

8. Ammonia is a stronger ligand than water. Which is correct when concentrated aqueous ammonia solution is added to dilute aqueous copper(II) sulfate solution?

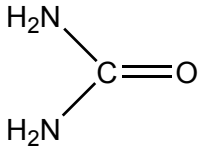
A. The d-orbitals in the copper ion split.

B. There is a smaller splitting of the d-orbitals.

C. Ammonia replaces water as a ligand.

D. The colour of the solution fades.

9. How many bonding electrons are there in the urea molecule?



A. 8

B. 16

C. 20

D. 24

10. Which does **not** show resonance?

A. PO_4^{3-}

B. C_6H_6

C. C_6H_{12}

D. O_3

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11. Which metal has the strongest metallic bond?

A. Li

B. Na

C. K

D. Rb

12. Which is the first step in the CFC-catalysed destruction of ozone in UV light?

A. $CCl_2F_2 \rightarrow CClF_2^+ + Cl^-$

B. $CCl_2F_2 \rightarrow \bullet CClF_2 + Cl\bullet$

C. $CCl_2F_2 \rightarrow CCl_2F^+ + F^-$

D. $CCl_2F_2 \rightarrow \bullet CCl_2F + F\bullet$

13. Which statement is correct?

A. Sigma bonds are formed only by the combination of s atomic orbitals.

B. Pi bonds can be formed in the absence of sigma bonds.

C. Pi bonds are formed parallel to the axis between atoms.

D. Pi bonds are formed only by the combination of hybrid orbitals.

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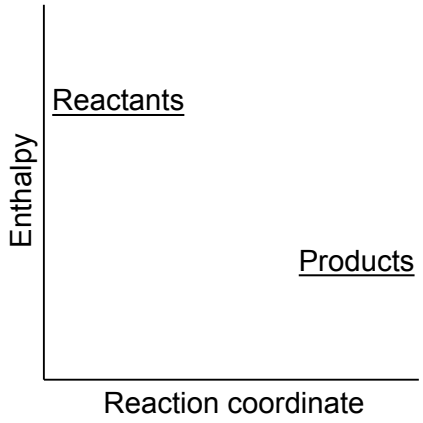
14. What can be deduced from this reaction profile?



A. The reactants are less stable than the products and the reaction is exothermic.

B. The reactants are less stable than the products and the reaction is endothermic.

C. The reactants are more stable than the products and the reaction is exothermic.

D. The reactants are more stable than the products and the reaction is endothermic.

15. What can be deduced from the facts that ozone absorbs UV radiation in the region of 340 nm and molecular oxygen in the region of 242 nm?

A. The bond between atoms in molecular oxygen is a double bond.

B. The bonds in ozone are delocalized.

C. The bonds between atoms in ozone are stronger than those in molecular oxygen.

D. The bonds between atoms in molecular oxygen need more energy to break.

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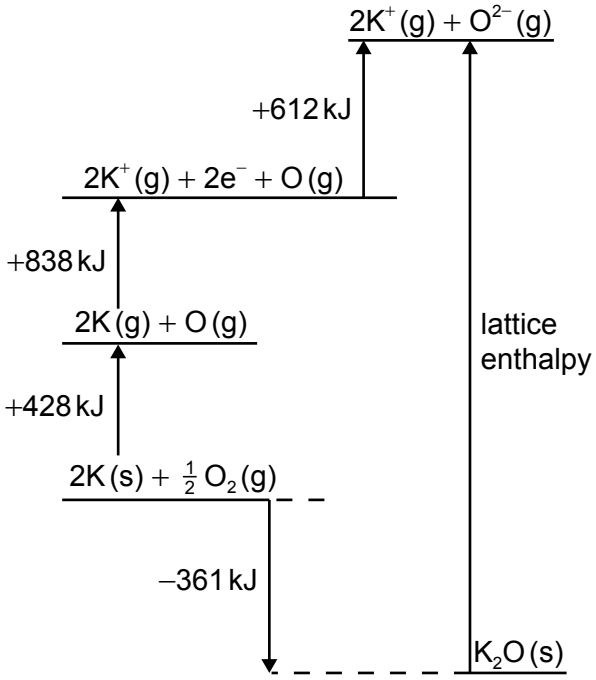
16. The Born-Haber cycle for potassium oxide is shown below:



Which expression represents the lattice enthalpy in $kJ\,mol^{-1}$?

A. $-361 + 428 + 838 + 612$

B. $-(-361) + 428 + 838 + 612$

C. $-361 + 428 + 838 - 612$

D. $-(-361) + 428 + 838 - 612$

17. Which ion's hydration energy is the most exothermic?

A. Li^+

B. Na^+

C. Br^-

D. I^-

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Questions 18 and 19 refer to the following reaction.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

18. Which change does **not** increase the initial rate of reaction when $CaCO_3(s)$ is added to excess $HCl(aq)$?

A. Decrease in the size of the $CaCO_3(s)$ particles

B. Increase in the temperature of the reaction mixture

C. Increase in the concentration of $HCl(aq)$, keeping the same volume

D. Increase in the volume of $HCl(aq)$, keeping the same concentration

19. Which methods can be used to monitor the progress of this reaction?

I. Change in colour of this reaction mixture
II. Change in mass of this reaction mixture
III. Change in volume of gas evolved

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

20. Which is true of an Arrhenius plot of $\ln k$ (y-axis) against $\frac{1}{T}$?

A. The graph goes through the origin.

B. The activation energy can be determined from the gradient.

C. The intercept on the x-axis is the activation energy.

D. The intercept on the y-axis is the frequency factor, A.

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21. Which is correct about reaction mechanisms?

A. A species that is zero order does not take part in the reaction.

B. A catalyst does not take part in the reaction.

C. Reactants in a fast step before the slow step are included in the rate expression.

D. Reactants in a fast step after the slow step are included in the rate expression.

22. Which variable affects the equilibrium constant, K_c?

A. Atmospheric pressure

B. Catalyst

C. Concentration of reactants

D. Temperature

23. Components X and Y are mixed together and allowed to reach equilibrium. The concentrations of X, Y, W and Z in the equilibrium mixture are 4, 1, 4 and 2 mol dm^{-3} respectively.

$$X + 2Y \rightleftharpoons 2W + Z$$

What is the value of the equilibrium constant, K_c?

A. $\frac{1}{8}$

B. $\frac{1}{2}$

C. 2

D. 8

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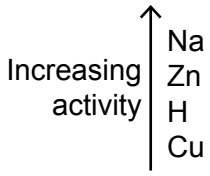
24. Which of the following does **not** react with dilute HCl (aq)?

Extract from activity series



A. Na_2CO_3

B. Cu

C. Zn

D. CuO

25. Which of the following is correct?

A. A weak acid is a proton donor and its aqueous solution shows good conductivity.

B. A weak acid is a proton donor and its aqueous solution shows poor conductivity.

C. A weak acid is a proton acceptor and its aqueous solution shows good conductivity.

D. A weak acid is a proton acceptor and its aqueous solution shows poor conductivity.

26. Which type of bond is formed when a Lewis acid reacts with a Lewis base?

A. Covalent

B. Dipole-dipole

C. Double

D. Hydrogen

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27. What is the order of increasing acidity of the following acids?

Acid	K_a
chloroethanoic	1.3×10^{-3}
ethanoic	1.7×10^{-5}

Acid	pK_a
hydrogen fluoride	3.3
hydrogen cyanide	9.3

A. chloroethanoic < ethanoic < hydrogen fluoride < hydrogen cyanide

B. ethanoic < chloroethanoic < hydrogen fluoride < hydrogen cyanide

C. chloroethanoic < ethanoic < hydrogen cyanide < hydrogen fluoride

D. hydrogen cyanide < ethanoic < hydrogen fluoride < chloroethanoic

28. Which element is reduced in the following decomposition?

$$(NH_4)_2Cr_2O_7(s) \rightarrow N_2(g) + Cr_2O_3(s) + 4H_2O(g)$$

A. N

B. H

C. Cr

D. O

29. Which of the following is **not** a redox reaction?

A. $CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$

B. $C(s) + O_2(g) \rightarrow CO_2(g)$

C. $2CO(g) \rightarrow CO_2(g) + C(s)$

D. $CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$

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30. What is the standard half-cell potential of copper if the "zero potential reference electrode" is changed from the standard hydrogen electrode to a standard zinc electrode?

	$E^{\ominus}$ / V with respect to the standard hydrogen electrode
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	−0.76
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34

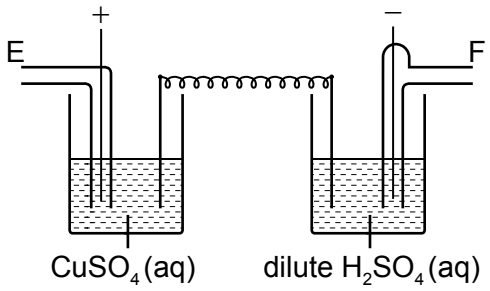
A. −1.1

B. −0.34

C. +0.34

D. +1.1

31. What are the relative volumes of gas given off at E and F during electrolysis of the two cells in series? Assume all electrodes are inert.



A. 1:1

B. 1:2

C. 2:1

D. 5:2

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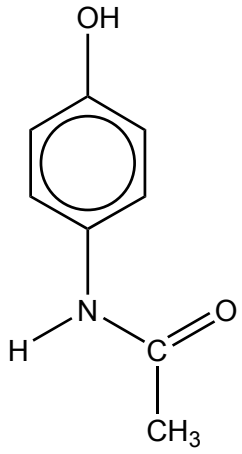
32. Which functional group is present in paracetamol?



A. Carboxyl

B. Amino

C. Nitrile

D. Hydroxyl

33. Which describes the reaction between a halogen and ethane?

	Mechanism	**Bond fission in halogen**
A.	free radical	homolytic
B.	free radical	heterolytic
C.	addition	homolytic
D.	addition	heterolytic

34. Which compound contains a secondary carbon atom?

A. $CH_3CH(Cl)CH(CH_3)_2$

B. $(CH_3)_2CHCH_2Cl$

C. $(CH_3)_3CCl$

D. CH_3CH_2Cl

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35. Which pair of isomers always shows optical activity?

A. Cis-trans

B. Enantiomers

C. Conformational

D. E/Z

36. Which compounds can be reduced?

I. C_2H_4
II. CH_3COOH
III. CH_3CHO

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

37. In which order should the reagents be used to convert benzene into phenylamine (aniline)?

	1st reagent	**2nd reagent**	**3rd reagent**
A.	NaOH	Sn / conc. HCl	conc. HNO_3 / conc. H_2SO_4
B.	Sn / conc. HCl	NaOH	conc. HNO_3 / conc. H_2SO_4
C.	conc. HNO_3 / conc. H_2SO_4	Sn / conc. HCl	NaOH
D.	NaOH	conc. HNO_3 / conc. H_2SO_4	Sn / conc. HCl

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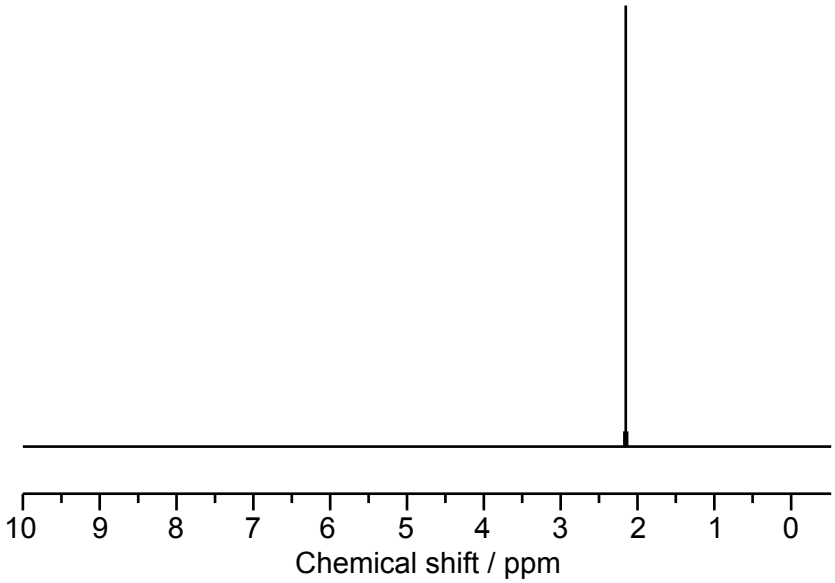
38. What can be deduced from the following ^{1}H NMR spectrum?



A. There is only one hydrogen atom in the molecule.

B. There is only one hydrogen environment in the molecule.

C. The molecule is a hydrocarbon.

D. There is only one isotope in the element.

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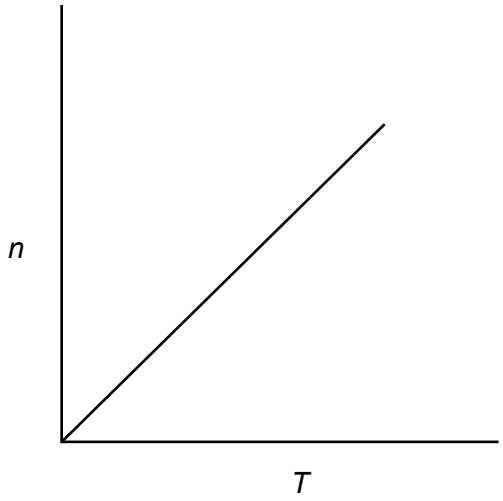
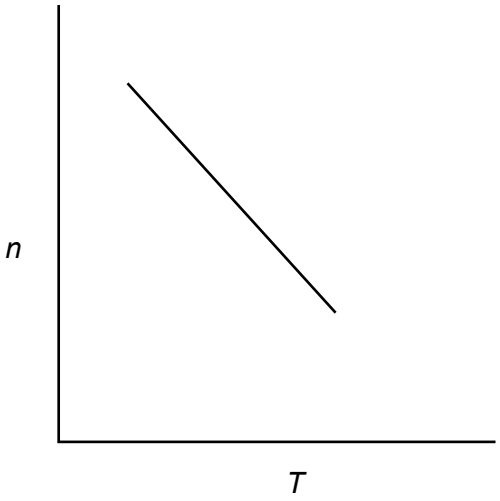
39. What is the graphical relationship between n and T in the ideal gas equation, $pV = nRT$, all other variables remaining constant?

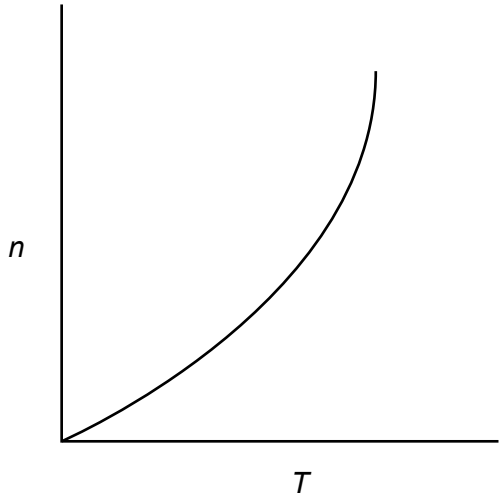
A.



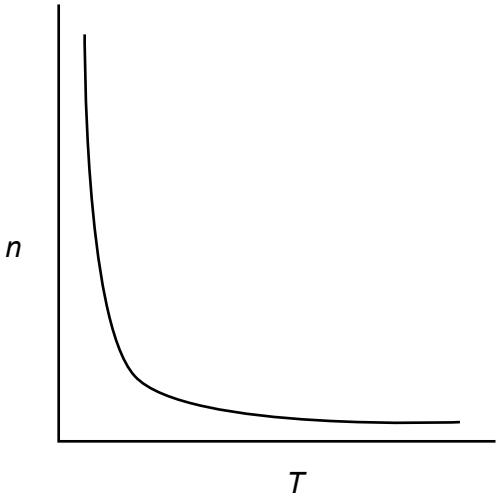
B.



C.



D.



40. Which technique can be used to identify bond length and bond angle?

A. ^{1}H NMR spectroscopy

B. IR spectroscopy

C. Mass spectroscopy

D. X-ray crystallography

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