Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Higher level
Paper 1

Friday 13 November 2015 (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]**.

8815–6101

The Periodic Table

1	2											3	4	5	6	7	0
1 **H** 1.01																	2 **He** 4.00
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
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.90	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.71	29 **Cu** 63.55	30 **Zn** 65.37	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** 98.91	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.40	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.30
55 **Cs** 132.91	56 **Ba** 137.34	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.21	76 **Os** 190.21	77 **Ir** 192.22	78 **Pt** 195.09	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.37	82 **Pb** 207.19	83 **Bi** 208.98	84 **Po** (210)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)															

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** 146.92	62 **Sm** 150.35	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.92	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (242)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

1. Which compound's molecular formula is the same as its empirical formula?

A. C_2H_5OH

B. CH_3COOH

C. C_6H_6

D. C_8H_{18}

2. The equation for the **complete** combustion of propene, C_3H_6, is shown below.

$$2C_3H_6(g) + 9O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$$

Which mixture, when ignited, will lead to **incomplete** combustion and the formation of CO (g)?

A. $2\,dm^3$ of propene and $10\,dm^3$ of oxygen

B. $0.5\,dm^3$ of propene and $2.3\,dm^3$ of oxygen

C. $1\,dm^3$ of propene and $4\,dm^3$ of oxygen

D. $3\,dm^3$ of propene and $14\,dm^3$ of oxygen

3. What is the percentage yield when 1.1 g of ethanal, CH_3CHO, is obtained from 4.6 g of ethanol, CH_3CH_2OH? $M_r(CH_3CH_2OH) = 46$; $M_r(CH_3CHO) = 44$

$$CH_3CH_2OH(l) + [O] \rightarrow CH_3CHO(l) + H_2O(l)$$

A. $\frac{1.1 \times 46 \times 100}{44 \times 4.6}$

B. $\frac{1.1 \times 100}{4.6}$

C. $\frac{4.6 \times 44 \times 100}{4.6 \times 1.1}$

D. $\frac{1.1 \times 46}{44 \times 4.6}$

4. Which stage of operation immediately follows ionization in the mass spectrometer?

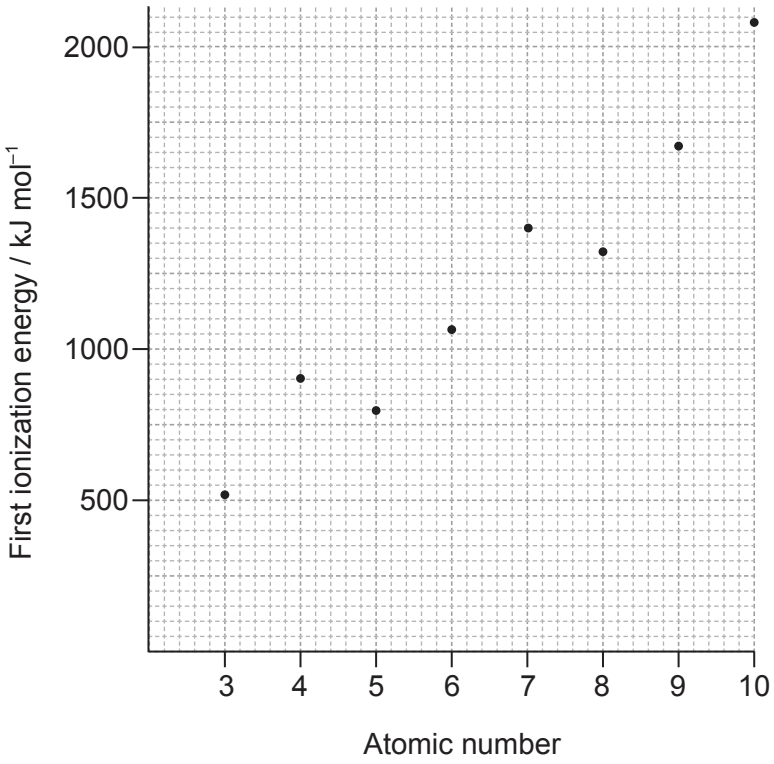
A. Acceleration

B. Deflection

C. Detection

D. Vaporization

5. Which statement is correct about the first ionization energies of consecutive elements shown in the graph?



[Source: Values from Nuffied Advance Science - Book of Data, Revised Edition (1984)]

A. The graph falls between Be and B because there is an electron in the third energy level.

B. The graph increases from B to N because the atomic radius is increasing.

C. The graph increases from Li to Ne because the number of electrons is increasing.

D. The graph falls between Be and B because the outer electron in B is in a p sub-level.

6. Which element has the greatest first ionization energy?

A. Al

B. Ar

C. Cl

D. Cs

7. Which elements are in the same group of the periodic table?

A. Ca, Na, Rb, Sr

B. Al, Ar, Cl, S

C. Au, Hg, Pb, Pt

D. As, Bi, P, Sb

8. Which property of transition metals enables them to behave as catalysts?

A. High melting point

B. Variable oxidation number

C. High density

D. Split d sub-levels

9. Which statement best describes the lattice structure of solid sodium chloride?

A. Each sodium ion is surrounded by one chloride ion.

B. Each chloride ion is surrounded by two sodium ions.

C. Each chloride ion is surrounded by four sodium ions.

D. Each sodium ion is surrounded by six chloride ions.

10. Which compound is most likely to contain ionic bonding?

A. ClO_2

B. CsCl

C. SCl_2

D. $SiCl_4$

11. Which molecule is polar?

A. C_2H_6

B. CH_2Cl_2

C. CO_2

D. CCl_4

12. What is the shape of the hexacyanoferrate(III) ion, $[Fe(CN)_6]^{3-}$?

A. Square planar

B. Hexagonal

C. Octahedral

D. Trigonal bipyramidal

13. Which set contains two or more species with delocalized π electrons?

A. CH_3CH_3, $H_2C{=}CH_2$, $H_2C{=}O$

B. $NaCl$, C_6H_6, $H_2C{=}O$

C. CO_3^{2-}, C_6H_6, C_6H_{12}

D. O_2, CH_3COCH_3, CH_3COOCH_3

14. Which of the following changes are exothermic?

I. $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

II. $2C_8H_{18}(g) + 17O_2(g) \rightarrow 16CO(g) + 18H_2O(g)$

III. $C_8H_{18}(g) \rightarrow C_8H_{18}(l)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

15. Which change represents the standard enthalpy change of formation?

A. The formation of 1 mol of a compound in its standard state from its gaseous atoms

B. The formation of 1 mol of a compound in its standard state from its elements

C. The formation of 1 mol of a compound in its standard state from its gaseous atoms in their standard states

D. The formation of 1 mol of a compound in its standard state from its elements in their standard states

16. Which equation represents electron affinity?

A. $C(g) + e^- \rightarrow C^-(g)$

B. $Na^+(aq) + e^- \rightarrow Na(s)$

C. $\frac{1}{2}Cl_2(g) + e^- \rightarrow Cl^-(g)$

D. $B(g) + e^- \rightarrow B^+(g) + 2e^-$

17. Which combination results in an ionic compound having the **greatest** magnitude of lattice enthalpy?

	Sum of ionic radii	Ionic charges
A.	small	large
B.	large	large
C.	large	small
D.	small	small

18. Under which conditions does a sample of the same mass of carbon dioxide have the **lowest** entropy value?

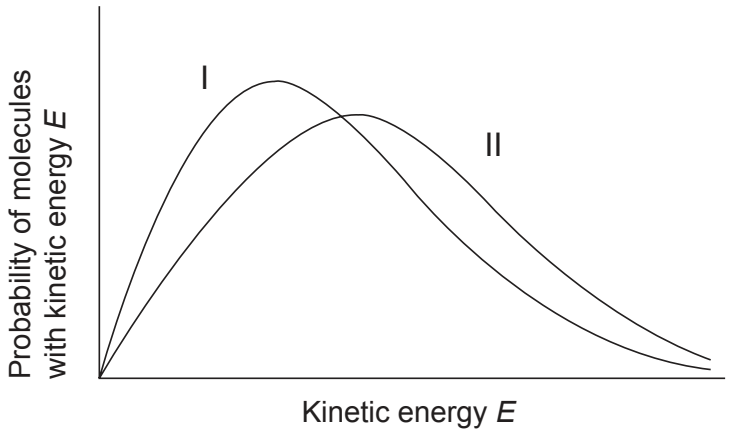
A. Solid at high temperature

B. Solid at low temperature

C. Gas at high temperature

D. Gas at low temperature

19. Curves I and II represent samples of the same gas at a constant pressure but at different temperatures. The areas under curves I and II are equal. What does curve II represent?



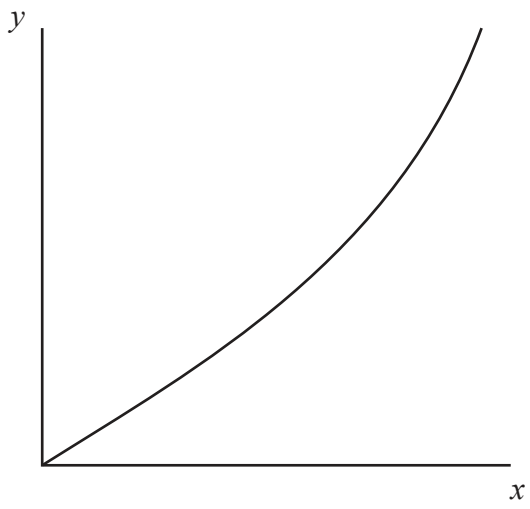
A. Curve II is at the lower temperature and there are less molecules in the sample.

B. Curve II is at the lower temperature and there are the same number of molecules in the samples.

C. Curve II is at the higher temperature and there are more molecules in the sample.

D. Curve II is at the higher temperature and there are the same number of molecules in the samples.

20. The graph shows a plot for a reaction with second-order kinetics. How should the axes be labelled?



	***x*-axis**	***y*-axis**
A.	concentration	time
B.	time	concentration
C.	rate	concentration
D.	concentration	rate

21. Which factors affect the rate constant, *k*, of a reaction?

I. Catalyst
II. Concentration of reactants
III. Temperature

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

22. Which best describes a reaction in a state of equilibrium?

A. The rates of the forward and reverse reactions are zero and the concentrations of products and reactants are equal.

B. The rate of the forward reaction equals the rate of the reverse reaction and the concentrations of products and reactants are equal.

C. The rates of the forward and reverse reactions are zero and the concentrations of products and reactants are constant.

D. The rate of the forward reaction equals the rate of the reverse reaction and the concentrations of products and reactants are constant.

23. The equilibrium concentrations of X, Y, Z and W are 1, 2, 4 and 2 $mol\,dm^{-3}$ respectively.

$$X(g) + 2Y(g) \rightleftharpoons Z(g) + W(g)$$

What is the value of the equilibrium constant, K_c?

A. 0.25

B. 0.5

C. 2

D. 4

24. Which of the following molecules can act as a Lewis acid but not as a Brønsted–Lowry acid?

A. BF_3

B. PCl_3

C. NH_3

D. H_2O

25. Which is a 0.001 $mol\,dm^{-3}$ solution of a weak acid?

	Conductivity	pH
A.	poor	5
B.	good	7
C.	poor	10
D.	good	3

26. What is the order of increasing acid strength? Approximate K_a and pK_a values at 298 K are given.

	K_a
$ClCH_2COOH$	1×10^{-3}
CH_3CH_2COOH	1×10^{-5}

	pK_a
C_6H_5OH	10.0
$C_6H_5NH_3^+$	4.6

A. $ClCH_2COOH < CH_3CH_2COOH < C_6H_5NH_3^+ < C_6H_5OH$

B. $C_6H_5OH < C_6H_5NH_3^+ < ClCH_2COOH < CH_3CH_2COOH$

C. $C_6H_5OH < C_6H_5NH_3^+ < CH_3CH_2COOH < ClCH_2COOH$

D. $C_6H_5OH < CH_3CH_2COOH < C_6H_5NH_3^+ < ClCH_2COOH$

27. Which solutions, mixed in equal concentrations and volumes, form an acid buffer solution?

A. $HCl(aq) + NaCl(aq)$

B. $CH_3CO_2H(aq) + CH_3CO_2Na(aq)$

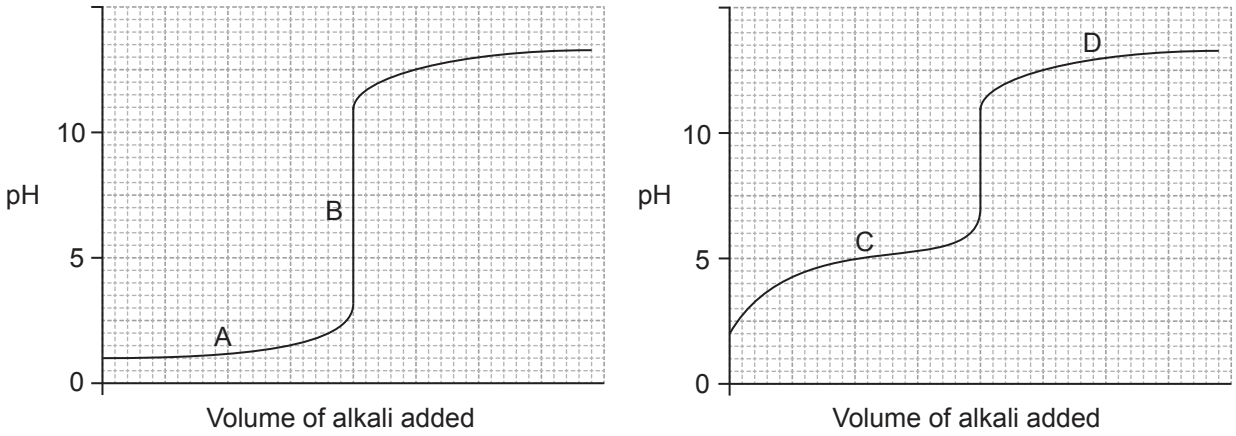
C. $CH_3CO_2H(aq) + NaOH(aq)$

D. $CH_3CO_2H(aq) + CH_3CH_2CO_2H(aq)$

28. Which salt forms the most acidic solution when dissolved in water?

	Salt	Ionic radius of cation / 10^{-12} m
A.	$CrCl_3$	63
B.	$FeCl_2$	76
C.	$MgCl_2$	65
D.	NaCl	98

29. What is the buffer region in the acid–base titration curves below?



30. Which element undergoes reduction in the following reaction?

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

A. Cr

B. H

C. N

D. O

31. Which best describes reduction?

A. Increase in oxidation number and gain of electrons

B. Increase in oxidation number and loss of electrons

C. Decrease in oxidation number and gain of electrons

D. Decrease in oxidation number and loss of electrons

32. What is $E^{\ominus}$, in V, for the following reaction?

$$VO^{2+}(aq) + 2H^{+}(aq) + V^{2+}(aq) \rightarrow 2V^{3+}(aq) + H_2O(l)$$

	Standard electrode potential, $E^{\ominus}$ / V
$V^{2+}(aq) + 2e^{-} \rightleftharpoons V(s)$	−1.18
$V^{3+}(aq) + e^{-} \rightleftharpoons V^{2+}(aq)$	−0.26
$VO^{2+}(aq) + 2H^{+}(aq) + e^{-} \rightleftharpoons V^{3+}(aq) + H_2O(l)$	+0.34
$VO_2^{+}(aq) + 2H^{+}(aq) + e^{-} \rightleftharpoons VO^{2+}(aq) + H_2O(l)$	+1.00

A. −0.60

B. +0.08

C. +0.60

D. +1.26

33. What product is formed at the positive electrode (anode) when 0.001 mol dm^{-3} $H_2SO_4(aq)$ is electrolysed?

A. Hydrogen

B. Oxygen

C. Sulfur

D. Sulfur dioxide

34. Which pair of compounds can be distinguished by reacting them with dilute bromine water in the dark?

A. CH_3CH_2COOH and CH_3CH_2CHO

B. $CH_3CH_2CHCHCH_3$ and $CH_3CH_2CH_2CH_2CH_3$

C. $CH_3CH_2CH(CH_3)_2$ and $CH_3CH_2CH_2CH_2CH_3$

D. $CH_3CH_2CH_2CHBrCH_3$ and $CH_3CH_2CHBrCH_2CH_3$

35. Which compound is most soluble in water?

A. CH_3CH_2CHO

B. $CH_3CH_2CH_2CHO$

C. $CH_3CH_2CO_2H$

D. $CH_3CH_2CH_2CO_2H$

36. Which are features of successive members of a homologous series?

I. Similar chemical properties
II. Same general formula
III. Differ by $-CH_2-$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

37. Which formula represents propanenitrile?

A. CH_3CH_2CN

B. $CH_3CH_2CH_2CN$

C. $CH_3CH_2CH_2NH_2$

D. $CH_3CH(NH_2)CH_3$

38. Which halogenoalkane reacts fastest with warm NaOH (aq)?

A. $(CH_3)_3CCl$

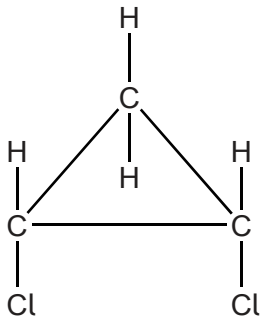
B. $(CH_3)_3CBr$

C. $CH_3CH_2CH_2CH_2Cl$

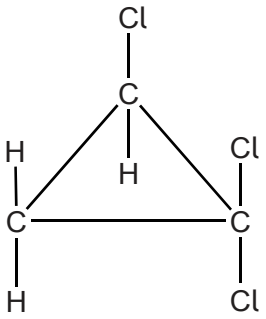
D. $CH_3CH_2CH_2CH_2Br$

39. Which is the geometric isomer of *cis*-1,2-dichlorocyclopropane?

A.



B.



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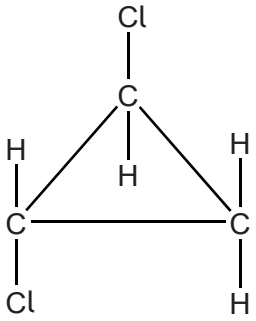

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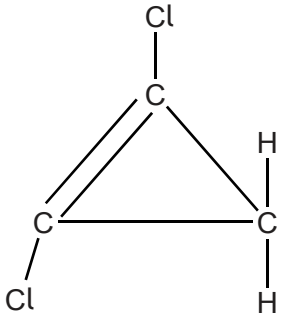
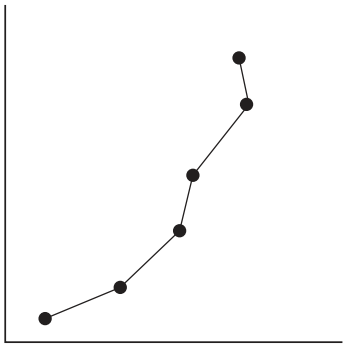
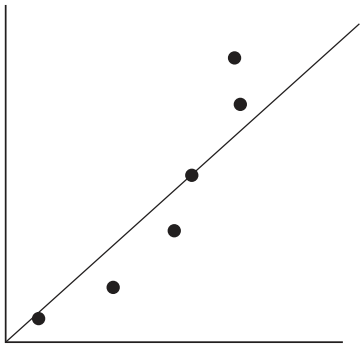


40. Which is the best-fit line or best-fit curve for the points plotted on the graph?

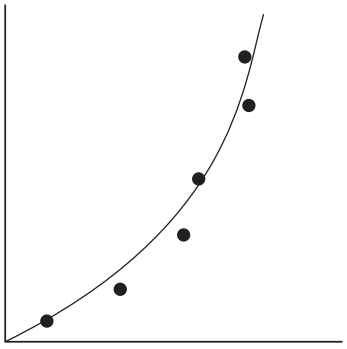
A.



B.



C.



D.