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CHEMISTRY
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PAPER 1

Tuesday 18 November 2014 (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]*.

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. 0.040 mol of $(NH_4)_2Ni(SO_4)_2 \cdot 6H_2O$ is dissolved in water to give 200 cm^3 of aqueous solution. What is the concentration, in mol dm^{-3}, of ammonium ions?

A. 0.00040

B. 0.0080

C. 0.20

D. 0.40

2. When sodium bromate(V), $NaBrO_3$, is heated, it reacts according to the equation below.

$$2NaBrO_3(s) \rightarrow 2NaBr(s) + 3O_2(g)$$

What amount, in mol, of $NaBrO_3$ produces 2.4 dm^3 of oxygen gas, measured at room temperature and pressure? (Molar volume of gas = 24 $dm^3\,mol^{-1}$ at room temperature and pressure.)

A. 0.017

B. 0.067

C. 0.10

D. 0.15

3. At which temperature, in K, assuming constant pressure, is the volume of a fixed mass of gas at 127 °C doubled?

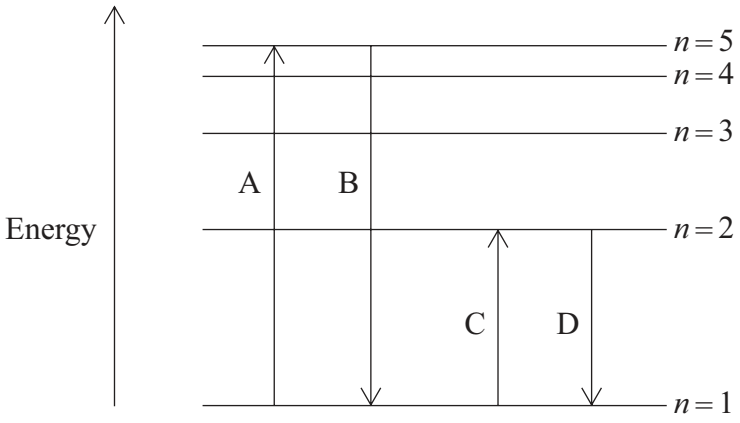
A. 200 K

B. 254 K

C. 400 K

D. 800 K

4. Some possible electron transitions in a hydrogen atom are shown below. Which letter represents the electron transition with the highest energy in the emission spectrum of a hydrogen atom?



5. Successive ionization energies for an element, **Z**, are shown in the table below.

Electrons removed	1st	2nd	3rd	4th	5th
Ionization energy / kJ mol^{-1}	736	1450	7740	10 500	13 600

What is the most likely formula for the ion of **Z**?

A. Z^{+}

B. Z^{2+}

C. Z^{3+}

D. Z^{4+}

6. Which statements are correct for the oxides of period 3 going from Na to Cl?

I. The oxides become increasingly acidic.

II. The bonding of the oxides changes from ionic to covalent.

III. All the oxides dissolve readily in water.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

7. The elements argon, potassium, and calcium are consecutive in the periodic table. Which gives the correct order of **increasing** first ionization energies?

A. Ar < Ca < K

B. K < Ar < Ca

C. Ca < K < Ar

D. K < Ca < Ar

8. Cobalt forms the complex $[Co(NH_3)_5Cl]^{2+}$. Which statements are correct for this complex?

I. The cobalt ion acts as a Lewis acid.

II. The cobalt ion has an oxidation number of +II.

III. There are 90° bond angles between the cobalt ion and the ligands.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

9. Which species contains a dative covalent (coordinate) bond?

A. HCN

B. C_2H_2

C. CO_2

D. CO

10. Which sequence has the molecules in order of increasing nitrogen-nitrogen bond length?

A. $N_2 < N_2H_4 < N_2H_2$

B. $N_2 < N_2H_2 < N_2H_4$

C. $N_2H_4 < N_2H_2 < N_2$

D. $N_2H_2 < N_2H_4 < N_2$

11. Which process involves the breaking of hydrogen bonds?

A. $2HI(g) \rightarrow H_2(g) + I_2(g)$

B. $CH_4(g) \rightarrow C(g) + 4H(g)$

C. $H_2(l) \rightarrow H_2(g)$

D. $NH_3(l) \rightarrow NH_3(g)$

12. What is the correct number of sigma (σ) and pi (π) bonds in prop-2-enenitrile, CH_2CHCN?

	σ bonds	**π bonds**
A.	7	2
B.	4	5
C.	6	3
D.	3	3

13. Which group of ions and molecules has delocalized electrons in **all** the species?

A. CH_3COCH_3, $C_2H_5COO^-$ and O_3

B. NO_3^-, NO_2^- and CO_2

C. C_6H_6, CO_3^{2-} and graphite

D. C_6H_6, CO_3^{2-} and C_2H_2

14. Consider the following equations.

$$2Fe(s) + 1\tfrac{1}{2}O_2(g) \rightarrow Fe_2O_3(s) \qquad \Delta H^{\ominus} = x$$
$$CO(g) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g) \qquad \Delta H^{\ominus} = y$$

What is the enthalpy change of the reaction below?

$$Fe_2O_3(s) + 3CO(g) \rightarrow 3CO_2(g) + 2Fe(s)$$

A. $3y - x$

B. $3y + x$

C. $-3y - x$

D. $-3y + x$

15. Consider the following bond enthalpy data.

Bond	Bond enthalpy / kJ mol^{-1}
H–H	436
Cl–Cl	243
H–Cl	432

What is the enthalpy change, in kJ mol^{-1}, of this reaction?

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

A. +247

B. –247

C. –185

D. +185

16. Which processes have a negative value for $\Delta S^{\ominus}$?

I. $H_2O(l) \rightarrow H_2O(s)$

II. $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

III. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

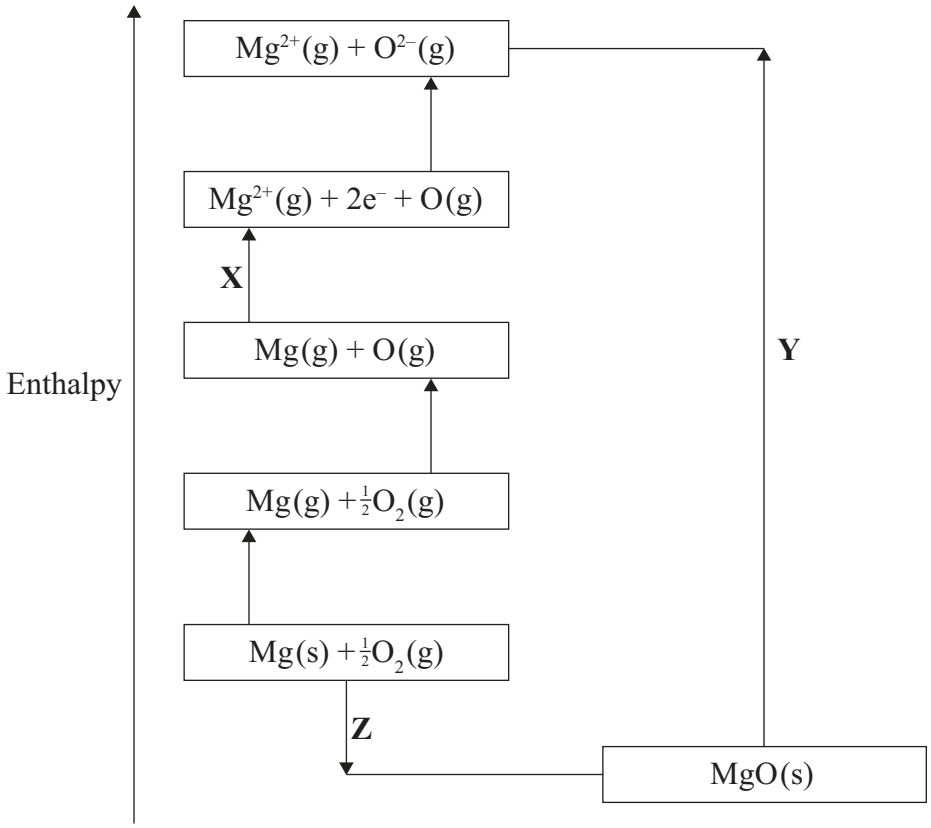
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

17. The Born–Haber cycle for the formation of magnesium oxide is shown below.



What is a correct description of the steps **X**, **Y** and **Z** in this cycle?

	Step X	Step Y	Step Z
A.	2nd ionization energy of Mg	enthalpy of formation of MgO	lattice enthalpy of MgO
B.	2nd ionization energy of Mg	lattice enthalpy of MgO	enthalpy of formation of MgO
C.	sum of the 1st and 2nd ionization energies of Mg	lattice enthalpy of MgO	enthalpy of formation of MgO
D.	sum of 1st and 2nd ionization energies of Mg	enthalpy of formation of MgO	lattice enthalpy of MgO

18. Consider the values of $\Delta H^{\ominus}$ and $\Delta S^{\ominus}$ for the reaction of nitrogen with oxygen at 298 K.

$$N_2(g) + O_2(g) \rightarrow 2NO(g) \qquad \Delta H^{\ominus} = +181\,kJ\,mol^{-1}$$
$$\Delta S^{\ominus} = +25\,J\,K^{-1}\,mol^{-1}$$

Which statement is correct for this reaction?

A. $\Delta G^{\ominus}$ is positive at all temperatures.

B. $\Delta G^{\ominus}$ is negative at all temperatures.

C. $\Delta G^{\ominus}$ is positive at high temperatures.

D. $\Delta G^{\ominus}$ is positive at low temperatures.

19. Consider the following reaction between hydrogen peroxide, hydrogen ions and iodide ions.

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

Which changes could be used to investigate the rate of this reaction?

I. Electrical conductivity

II. Mass of solution

III. Colour intensity

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

20. Consider the following reaction between nitrogen monoxide and oxygen.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

The reaction occurs in two steps:

Step 1:	$NO(g) + NO(g) \rightleftharpoons N_2O_2(g)$	*fast*
Step 2:	$N_2O_2(g) + O_2(g) \rightarrow 2NO_2(g)$	*slow*

What is the rate expression for this reaction?

A. Rate = $k[NO]^2$

B. Rate = $k[NO][O_2]$

C. Rate = $k[NO]^2[O_2]$

D. Rate = $k[NO][O_2]^2$

21. What happens to the rate constant, k, and the activation energy, E_a, as the temperature of a chemical reaction is increased?

	Value of k	**Value of E_a**
A.	increases	increases
B.	unchanged	increases
C.	decreases	unchanged
D.	increases	unchanged

22. Which equilibrium reaction shifts to the product side when the temperature is increased at constant pressure **and** to the reactant side when the total pressure is increased at constant temperature?

A. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H^{\ominus} < 0$

B. $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\Delta H^{\ominus} > 0$

C. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ $\Delta H^{\ominus} < 0$

D. $PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$ $\Delta H^{\ominus} > 0$

23. A mixture of 2.0 mol of H_2 and 2.0 mol of I_2 is allowed to reach equilibrium in the gaseous state at a certain temperature in a 1.0 dm^3 flask. At equilibrium, 3.0 mol of HI are present. What is the value of K_c for this reaction?

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

A. $K_c = \frac{(3.0)^2}{(0.5)^2}$

B. $K_c = \frac{3.0}{(0.5)^2}$

C. $K_c = \frac{(3.0)^2}{(2.0)^2}$

D. $K_c = \frac{(0.5)^2}{(3.0)^2}$

24. Which definition of a base is correct?

A. A Lewis base accepts a proton.

B. A Brønsted–Lowry base accepts an electron pair.

C. A Brønsted–Lowry base donates an electron pair.

D. A Lewis base donates an electron pair.

25. A student adds 0.3 g of magnesium metal to equal volumes of hydrochloric acid and ethanoic acid of the same concentrations in separate flasks. Which statement is correct?

A. Hydrochloric acid reacts more rapidly as it has a higher pH than ethanoic acid.

B. A greater total volume of H_2 gas is produced with hydrochloric acid than with ethanoic acid.

C. The same total volume of H_2 gas is produced with both hydrochloric acid and ethanoic acid.

D. Ethanoic acid reacts more slowly because it has a lower pH than hydrochloric acid.

26. Which compound will produce an aqueous solution which has a pH greater than 7?

A. $CuSO_4$

B. $FeCl_3$

C. Na_2CO_3

D. NH_4NO_3

27. Methylamine acts as a weak base when it reacts with water. For a diluted aqueous solution, what is the K_b expression for this reaction?

A. $K_b = \dfrac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]}$

B. $K_b = \dfrac{[CH_3NH_2][H_2O]}{[CH_3NH_3^+][OH^-]}$

C. $K_b = \dfrac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2][H_2O]}$

D. $K_b = \dfrac{[CH_3NH_2]}{[CH_3NH_3^+][OH^-]}$

28. A buffer solution is formed by mixing equal volumes of $1.00\,\text{mol}\,\text{dm}^{-3}$ propanoic acid and $0.500\,\text{mol}\,\text{dm}^{-3}$ potassium propanoate.

What is the concentration, in $\text{mol}\,\text{dm}^{-3}$, of $[H^+(aq)]$ in this buffer solution? (K_a for propanoic acid is 1.30×10^{-5}.)

A. 2.60×10^{-5}

B. 1.95×10^{-5}

C. 1.30×10^{-5}

D. 0.650×10^{-5}

29. The acid–base indicator phenol red, HIn, changes colour from yellow to red over a pH range of 6.6–8.2. Which statement is correct?

A. In a strongly acidic solution $[HIn] < [In^-]$.

B. The pK_a of phenol red is between 6.6 and 8.2.

C. The In^- ions are yellow.

D. Phenol red would be a suitable indicator for the titration of a strong acid and a weak base.

30. Which statement is correct for the following reaction?

$$2ClO_3^-(aq) + SO_2(aq) + H^+(aq) \rightarrow 2ClO_2(g) + HSO_4^-(aq)$$

A. ClO_3^- is the oxidizing agent and it undergoes reduction.

B. ClO_3^- is the reducing agent and it undergoes oxidation.

C. SO_2 is the oxidizing agent and it undergoes oxidation.

D. SO_2 is the reducing agent and it undergoes reduction.

31. Which species are produced at each electrode during the electrolysis of molten lead(II) bromide, $PbBr_2(l)$?

	Negative electrode (cathode)	Positive electrode (anode)
A.	$Br^-(l)$	$Pb^{2+}(l)$
B.	$Pb^{2+}(l)$	$Br^-(l)$
C.	$Br_2(g)$	$Pb(l)$
D.	$Pb(l)$	$Br_2(g)$

32. Consider the following standard electrode potentials.

$$Sn^{2+}(aq) + 2e^- \rightleftharpoons Sn(s) \qquad E^\ominus = -0.14\,V$$
$$H^+(aq) + e^- \rightleftharpoons \tfrac{1}{2}H_2(g) \qquad E^\ominus = 0.00\,V$$
$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq) \qquad E^\ominus = +0.77\,V$$

Which species will reduce $H^+(aq)$ to $H_2(g)$ under standard conditions?

A. $Fe^{2+}(aq)$

B. $Sn^{2+}(aq)$

C. $Sn(s)$

D. $Fe^{3+}(aq)$

33. A number of molten metal chlorides are electrolysed, using the same current for the same length of time. Which metal will be produced in the greatest amount, in mol?

A. Mg

B. Al

C. K

D. Ca

34. Which product is formed when bromine water is added to propene, CH_3CHCH_2?

A. $CH_3CBr_2CH_3$

B. $CH_2BrCH_2CH_2Br$

C. $CH_3CHBrCH_2Br$

D. $CH_3CH_2CH_2Br$

35. Which equation represents a propagation step in the reaction of methane with bromine?

A. $CH_4 \rightarrow CH_3\bullet + H\bullet$

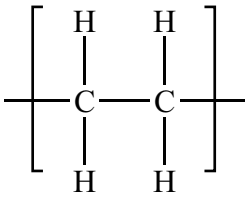
B. $CH_4 + Br\bullet \rightarrow CH_3\bullet + HBr$

C. $CH_4 + Br\bullet \rightarrow CH_3Br + H\bullet$

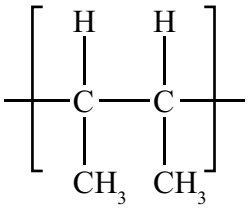
D. $CH_3\bullet + Br\bullet \rightarrow CH_3Br$

36. Which of these repeating units is present in the polymer poly(propene)?

A.



B.



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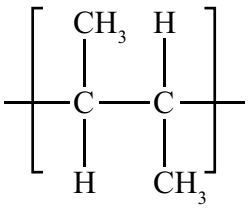
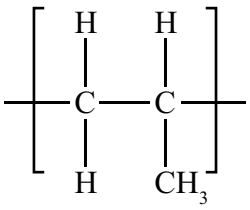


D.



37. Chloroethane, C_2H_5Cl, reacts with concentrated ammonia, NH_3, to form ethanamine, $C_2H_5NH_2$. Which statement about the mechanism of this reaction is correct?

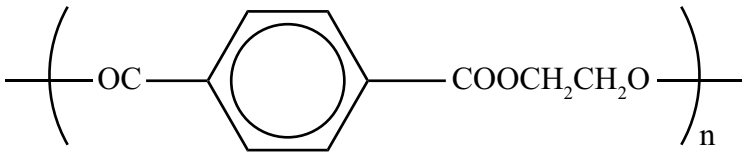
A. The reaction follows an S_N1 mechanism.

B. Homolytic fission of the carbon-chlorine bond occurs in chloroethane.

C. The reaction is unimolecular.

D. There is no charge on the transition state.

38. Which combination of monomers produces a condensation polymer with the repeating unit below?



A. C_6H_5COOH and $HOCH_2CH_2OH$

B. C_6H_5COOH and CH_3CH_2OH

C. $C_6H_4(COOH)_2$ and CH_3CH_2OH

D. $C_6H_4(COOH)_2$ and $HOCH_2CH_2OH$

39. Which type(s) of stereoisomerism, if any, is/are present in the molecule CH_2=CHCHBrCH_3?

A. Optical only

B. Geometric only

C. Optical and geometric

D. Neither optical nor geometric

40. In an experiment to determine a specific quantity, a student calculated that her experimental uncertainty was 0.9 % and her experimental error was 3.5 %. Which statement is correct?

A. Only random uncertainties are present in this experiment.

B. Both random uncertainties and systematic errors are present in this experiment.

C. Repeats of this experiment would reduce the systematic errors.

D. Repeats of this experiment would reduce both systematic errors and random uncertainties.