N12/4/CHEMI/HPM/ENG/TZ0/XX

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CHEMISTRY
HIGHER LEVEL
PAPER 1

Friday 9 November 2012 (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. What is the number of ions in 0.20 mol of $(NH_4)_3PO_4$?

A. 8.0×10^{-1}

B. 1.2×10^{23}

C. 4.8×10^{23}

D. 2.4×10^{24}

2. The equation for the reduction of iron(III) oxide is:

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

What mass of carbon dioxide, in g, is produced by the complete reduction of 80 g of iron(III) oxide?

A. 44

B. 66

C. 88

D. 132

3. 3.0 dm^3 of ethyne, C_2H_2, is mixed with 3.0 dm^3 of hydrogen and ignited. The equation for the reaction that occurs is shown below.

$$C_2H_2(g) + 2H_2(g) \rightarrow C_2H_6(g)$$

Assuming the reaction goes to completion and all gas volumes are measured at the same temperature and pressure, what volume of ethane, C_2H_6, in dm^3, is formed?

A. 1.5

B. 2.0

C. 3.0

D. 6.0

4. Which ion would be deflected the most in a mass spectrometer?

A. $^{35}Cl^{+}(g)$

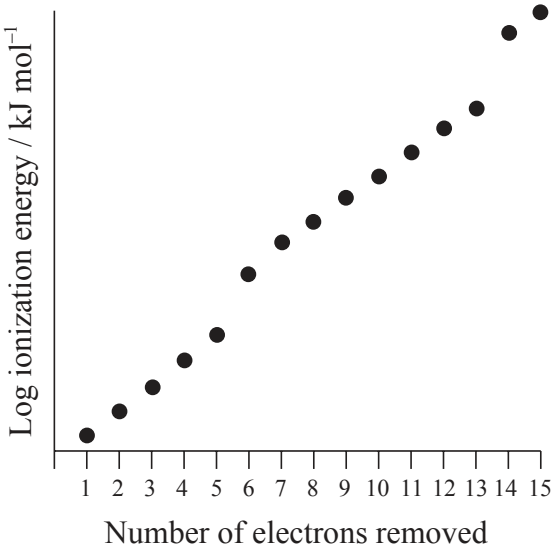
B. $^{37}Cl^{+}(g)$

C. $^{35}Cl^{2+}(g)$

D. $^{37}Cl^{2+}(g)$

5. Which of the graphs below shows the successive logarithmic ionization energies of phosphorus?

A.



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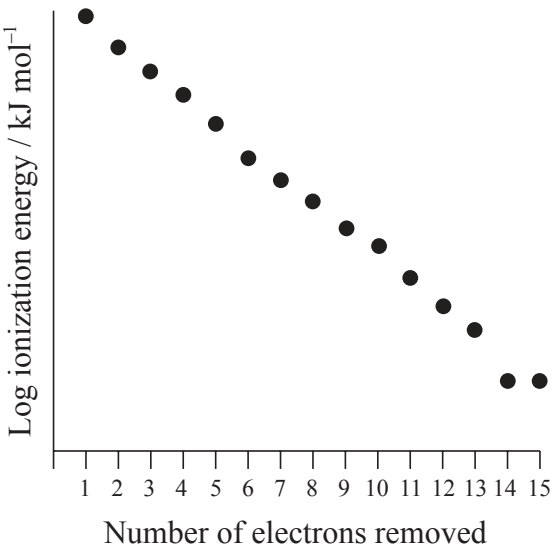

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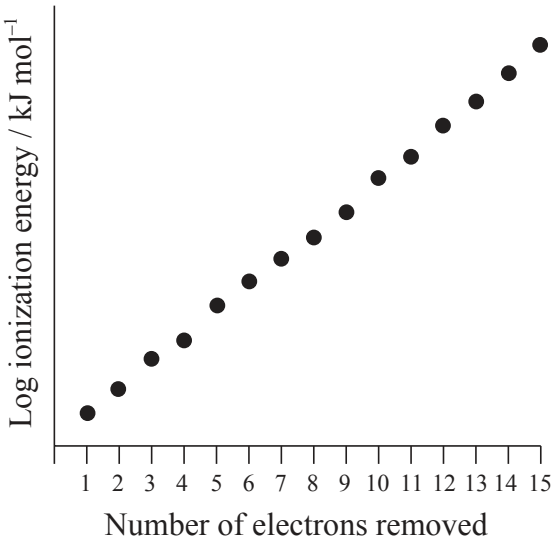
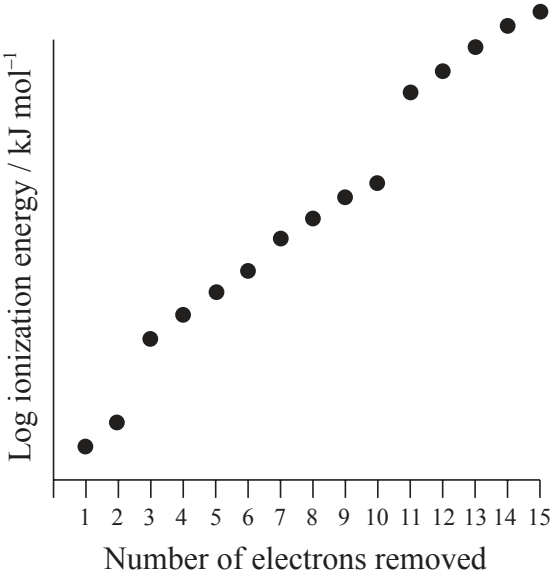


D.



6. Which combination is correct for the properties of the alkali metals from Li to Cs?

	Atomic radius	Melting point	First ionization energy
A.	increases	increases	increases
B.	increases	decreases	decreases
C.	increases	increases	decreases
D.	decreases	decreases	increases

7. Which equation represents a reaction that occurs under normal conditions?

A. $2LiBr(aq) + I_2(aq) \rightarrow 2LiI(aq) + Br_2(aq)$

B. $2KF(aq) + Cl_2(aq) \rightarrow 2KCl(aq) + F_2(aq)$

C. $2LiCl(aq) + I_2(aq) \rightarrow 2LiI(aq) + Cl_2(aq)$

D. $2KBr(aq) + Cl_2(aq) \rightarrow 2KCl(aq) + Br_2(aq)$

8. Which combination of statements about the oxides of period 3 elements is correct?

	State at room temperature			Electrical conductivity in molten state		
	Na_2O	Al_2O_3	P_4O_{10}	Na_2O	Al_2O_3	P_4O_{10}
A.	solid	solid	gas	good	good	good
B.	solid	solid	solid	good	good	poor
C.	solid	liquid	liquid	good	poor	poor
D.	solid	solid	solid	poor	poor	good

9. Which is an ionic compound?

A. Mg_3N_2

B. Al_2Cl_6

C. SiO_2

D. SF_6

10. Which molecule is polar?

	Molecule	Shape
A.	CO_2	linear
B.	SO_3	trigonal planar
C.	CCl_4	tetrahedral
D.	SO_2	bent (V-shaped)

11. Which intermolecular forces are present in HI (l)?

I. Hydrogen bonding

II. Dipole-dipole forces

III. Van der Waals' (London dispersion) forces

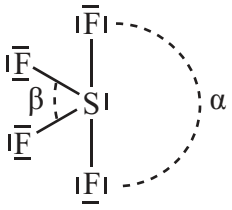
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

12. In the molecule SF_4, which are the correct bond angles?



	α / °	**β / °**
A.	180	120
B.	187	103
C.	187	120
D.	180	90

13. Which substances have delocalized electrons in their structure?

I. Ethanal

II. Ozone

III. Benzene

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

14. A 5.00 g sample of a substance was heated from 25.0 °C to 35.0 °C using 2.00×10^2 J of energy. What is the specific heat capacity of the substance in J g^{-1} K^{-1}?

A. 4.00×10^{-3}

B. 2.50×10^{-1}

C. 2.00

D. 4.00

15. Using the equations below:

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H^{\ominus} = -390 \text{ kJ}$$
$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H^{\ominus} = -286 \text{ kJ}$$
$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \qquad \Delta H^{\ominus} = -890 \text{ kJ}$$

what is $\Delta H^{\ominus}$, in kJ, for the following reaction?

$$C(s) + 2H_2(g) \rightarrow CH_4(g)$$

A. –214

B. –72

C. +72

D. +214

16. Which is the best definition of electron affinity?

A. The ability of an atom to attract the electrons in a covalent bond.

B. The attraction of an atom for an electron.

C. The enthalpy change when an atom gains an electron.

D. The enthalpy change when a gaseous atom gains an electron.

17. Which is the best definition of the standard state?

A. The standard state of a solid is the most pure form of the solid.

B. The standard state of a solid is the most pure form of the solid at $298\,^{\circ}\text{C}$.

C. The standard state of a gas is the most pure form of the gas at $298\,^{\circ}\text{C}$.

D. The standard state of a gas is the most pure form of the gas at a pressure of 100 kPa.

18. Consider the following information:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$
$$\Delta H = +179 \text{ kJ mol}^{-1}$$
$$\Delta S = +161.0 \text{ J K}^{-1} \text{ mol}^{-1}$$

What happens to the spontaneity of this reaction as the temperature is increased?

A. The reaction becomes more spontaneous as the temperature is increased.

B. The reaction becomes less spontaneous as the temperature is increased.

C. The reaction remains spontaneous at all temperatures.

D. The reaction remains non-spontaneous at all temperatures.

19. Which piece of equipment could **not** be used in an experiment to measure the rate of this reaction?

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + H^+(aq) + I^-(aq)$$

A. A colorimeter

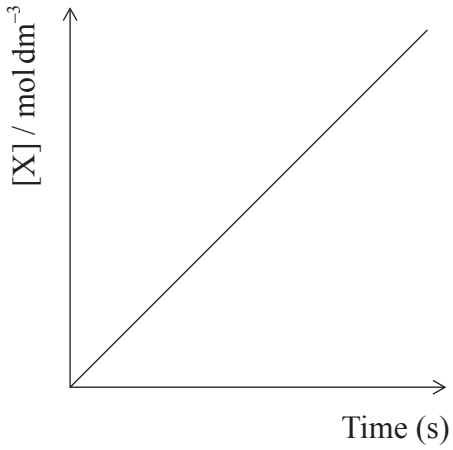
B. A gas syringe

C. A stopwatch

D. A pH meter

20. Which graph would be produced by a 2nd order reaction if the rate equation is rate $= k[X]^2$?

A.



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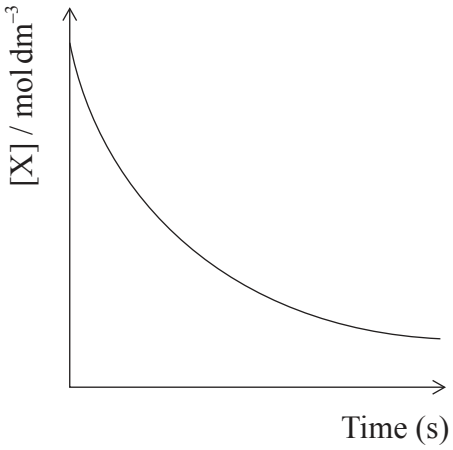

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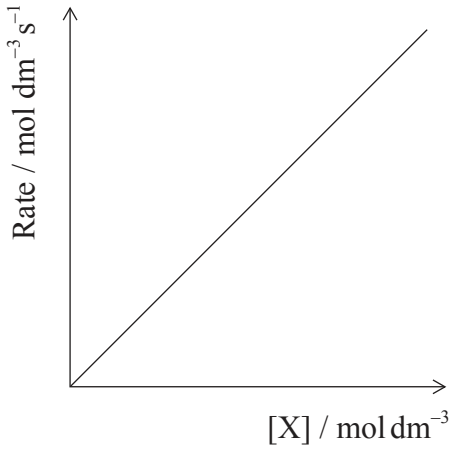

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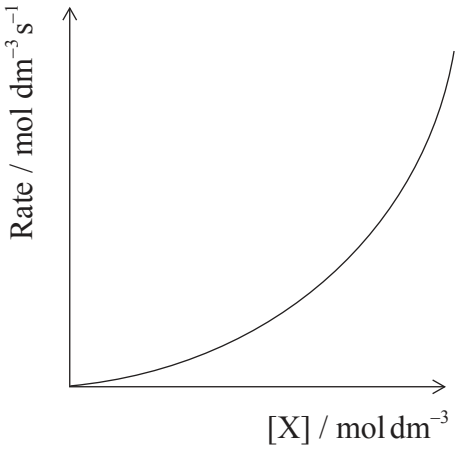

21. Which step in a multi-step reaction mechanism will be rate-determining?

A. The first step

B. The last step

C. The step with the highest activation energy

D. The step with the lowest activation energy

22. Iron(III) ions, Fe^{3+}, react with thiocyanate ions, SCN^-, in a reversible reaction to form a red solution. Which changes to the equilibrium will make the solution go red?

$$Fe^{3+}(aq) + SCN^-(aq) \rightleftharpoons [FeSCN]^{2+}(aq) \qquad \Delta H^\ominus = +ve$$

Yellow Red

I. Increasing the temperature

II. Adding $FeCl_3$

III. Adding a catalyst

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

23. Consider the following reversible reaction:

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

What is the value of K_c for the reaction when the equilibrium concentrations are $[NO_2] = 4.0\ mol\,dm^{-3}$ and $[N_2O_4] = 4.0\ mol\,dm^{-3}$?

A. 0.25

B. 0.50

C. 2.0

D. 4.0

24. Which substance can act as a Lewis acid but not as a Brønsted–Lowry acid?

A. HCl

B. CH_3COOH

C. BF_3

D. CF_3COOH

25. Which row correctly describes 1.0 mol dm^{-3} NaOH (aq)?

	pH	Colour in universal indicator solution	Electrical conductivity
A.	14	purple	good
B.	10	green	poor
C.	14	red	good
D.	10	blue	poor

26. For pure water at 50 °C, $K_w = 5.48 \times 10^{-14}$. What is the pH of this water?

A. 4.8

B. 6.6

C. 7.0

D. 8.2

27. Which is the strongest acid?

	Acid	pK_a
A.	chloroethanoic	2.87
B.	iodoethanoic	3.18
C.	benzoic	4.20
D.	pentanoic	4.83

28. Which salts will dissolve in water to give solutions with a pH above 7?

I. Na_2CO_3

II. CH_3COONa

III. Na_2SO_4

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

29. During a titration, 0.1 mol dm^{-3} sodium hydroxide is added to 0.1 mol dm^{-3} ethanoic acid. Which indicator would be the **best** to use as an end point indicator in this titration?

	Indicator	pH range of indicator
A.	methyl orange	3.2–4.4
B.	bromophenol blue	3.0–4.6
C.	bromothymol blue	6.0–7.6
D.	phenolphthalein	8.2–10.0

30. What is the correct systematic name of MnO_2?

A. Manganese(II) oxide

B. Manganese(IV) oxide

C. Magnesium(II) oxide

D. Magnesium(IV) oxide

31. A voltaic cell is made by connecting zinc and lead half-cells. The overall equation for the reaction occurring in the cell is shown below.

$$Zn(s) + Pb^{2+}(aq) \rightarrow Pb(s) + Zn^{2+}(aq)$$

Which statements are correct when the cell produces electricity?

I. The zinc is oxidized.

II. Electrons move from zinc to lead in the external circuit.

III. The mass of the lead electrode increases.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

32. Consider the following standard electrode potential values:

$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq) \qquad E^{\ominus} = +0.77\ V$$

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l) \qquad E^{\ominus} = +1.51\ V$$

What is the cell potential, in V, for this reaction?

$$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l) + 5Fe^{3+}(aq)$$

A. –2.28

B. –0.74

C. +0.74

D. +2.28

33. Consider the following standard electrode potential values:

$$Ca^{2+}(aq) + 2e^- \rightleftharpoons Ca(s) \qquad E^\ominus = -2.87\ V$$
$$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s) \qquad E^\ominus = -0.45\ V$$
$$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s) \qquad E^\ominus = -0.26\ V$$
$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq) \qquad E^\ominus = +0.77\ V$$

Which reaction is spontaneous?

A. $Ca^{2+}(aq) + Ni(s) \rightarrow Ca(s) + Ni^{2+}(aq)$

B. $3Fe^{2+}(aq) \rightarrow Fe(s) + 2Fe^{3+}(aq)$

C. $Fe(s) + 2Fe^{3+}(aq) \rightarrow 3Fe^{2+}(aq)$

D. $Fe^{2+}(aq) + Ni(s) \rightarrow Fe(s) + Ni^{2+}(aq)$

34. Which compound has the lowest boiling point?

A. $(CH_3)_3COH$

B. $CH_3(CH_2)_3OH$

C. $(CH_3)_4C$

D. $CH_3(CH_2)_3CH_3$

35. Which compound would decolourize bromine water in the dark?

A. $CH_3COCH_2CH_3$

B. $CH_3(CH_2)_4OH$

C. $CH_3CHCHCH_3$

D. $CH_3(CH_2)_3CH_3$

36. Which statement about the oxidation of alcohols is correct?

A. Oxidation of propan-1-ol produces propanone.

B. Mild oxidation of butan-1-ol produces butanal.

C. Strong oxidation of pentan-2-ol produces pentanoic acid.

D. Mild oxidation of butan-2-ol produces butanal.

37. Which halogenoalkane will react most quickly with sodium hydroxide?

A. $CH_3CH_2CH_2CH_2Cl$

B. $CH_3CH_2CH_2CH_2Br$

C. $(CH_3)_3CCl$

D. $(CH_3)_3CBr$

38. Which would be the main product of the reaction between 1-bromobutane and concentrated sodium hydroxide in hot ethanol?

A. $CH_2CHCH_2CH_3$

B. $CH_3CHCHCH_3$

C. $CH_3CH_2CH_2CH_3$

D. $CH_3CHOHCH_2CH_3$

39. Which molecules can react to form a condensation polymer with a dicarboxylic acid such as hexanedioic acid?

I. $HOCH_2CH_2OH$

II. $CH_3CH_2NH_2$

III. $H_2N(CH_2)_6NH_2$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

40. $50\ cm^3$ of copper(II) sulfate solution is measured into a plastic cup using a $100\ cm^3$ measuring cylinder. Excess zinc powder is added and the temperature rise that occurs is measured with a $-10\ ^\circ C$ to $+110\ ^\circ C$ thermometer. The enthalpy change for the reaction is then calculated. Which statement is correct?

A. Systematic error will be reduced by repeating the experiment several times and averaging the results.

B. Random error will be reduced by insulating the plastic cup.

C. Random error will be reduced by using a $50\ cm^3$ graduated pipette instead of a measuring cylinder.

D. Systematic error will be increased by using a larger volume of copper(II) sulfate solution.