ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2015
EXAMINATION CATEGORY: <u>TECHNICAL</u>

PAPER III: SUBJECT SPECIALIZATION PAPER for *Electrical/Electrical & Electronics Engineering*

Date	: 11 October 2015
Total Marks	: 100
Examination Time	: 150 minutes (2.5 hours)
Reading Time	: 15 Minutes (prior to examination time)

GENERAL INSTRUCTIONS:

1. Write your Roll Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is being provided to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A and SECTION B:
   - **SECTION A** has two parts: Part I -   30 Multiple-Choice Questions
                                                  Part II -   4 Short Answer Questions

   All questions under SECTION A are COMPULSORY.

   - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions under your choice.
4. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating any or correct Section, Part and Question Number will NOT be evaluated and no marks would be awarded.
5. Begin each Section and Part in a fresh page of the Answer Booklet.
6. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
7. Use of any other paper including paper for rough work is not permitted.
8. You are required to hand over the Answer Booklet to the Invigilator before leaving the examination hall.
9. This paper has **12** printed pages in all, including this instruction page.

GOOD LUCK!

SECTION A
PART I - Multiple Choice Questions (30 Marks)

Choose the correct answer and write down the letter of the correct answer chosen in the Answer Booklet against the question number. E.g. 31 (c). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. One coulomb of electrical charge is contributed by how many electrons?
   a) 0.625×10^{19}.
   b) 1.6×10^{19}.
   c) 10^{19}.
   d) 1.6×10^{12}.

2. In a RLC circuit (series) if C is increasing and remaining R and L are constants, then resonant frequency will
   a) increase.
   b) decrease.
   c) double.
   d) remain same.

3. In the figure shown, what will be the current passing through 2 Ω resistor?
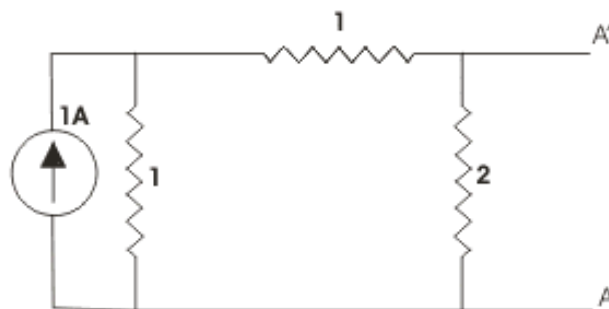
   a) 0.25 A
   b) 0.75 A
   c) 0.5 A
   d) 1 A

4. In a pnp transistor, the major carriers in the emitter are
   a) free electrons.
   b) holes.
   c) neither.
   d) both.

5. In a normally biased npn transistor, the electrons in the emitter have enough energy to overcome the barrier potential of the
   a) base - emitter junction.
   b) base – collector junction.
   c) collector – base junction.
   d) recombination path.

6. Internal resistance of a battery cell increases with
   a) increases in concentration of electrolyte.
   b) increase in distance between two electrodes.
   c) increases in area of the plates inside the electrolyte.
   d) increase in size of the electrodes.

7. Negative electrode or anode of simple voltaic cell is made of
   a) Copper.
   b) Zinc.
   c) Lead.
   d) Carbon.

8. Overload relays are of ….. type.
   a) induction
   b) solid state
   c) thermal
   d) electromagnetic

9. What is the most expensive part of an electric vehicle?
   a) electric motor
   b) body of the car
   c) battery
   d) controller

10. The equation for 25 cycles current sine wave having rms value of 30 amps, will be
    a) $42.4\sin50\pi t$

    b) $30\sin50\pi t$

    c) $30\sin25\pi t$

    d) $42.4\sin25\pi t$

11. The value of supply voltage for 400 W, 4 Ω load is
    a) 40 V

    b) 400 V

    c) 20 V

    d) 200 V

12. The time constant of an RL circuit is 1 second and its inductor is 8 H, the resistance of the coil is _____ Ω.
    a) 8

    b) 1/8

    c) 0.25

    d) 1

13. i) In star connection line, current is equal to phase current.
    ii) In delta connection line, voltage is equal to phase voltage.
    For a given phase connected to the particular line which of the statement is true?
    a) Only (i).

    b) Only (ii).

    c) Both (i) and (ii).

    d) None of these

14. A delta connection contains three equal impedance of 60 Ω. The impedance of the equivalent star connection for each star load will be
   a) 15 Ω.

    b) 20 Ω.

    c) 30 Ω.

    d) 40 Ω.

15. Three element having conductance G1, G2 and G3 are connected in parallel. Their combined conductance will be
    a) $1/(G1 + G2 + G3)$.
    b) $G1 + G2 + G3$.
    c) $1/G1 + 1/G2 + 1/G3$.
    d) $(1/G1 + 1/G2 + 1/G3) - 1$.

16. Which of the following materials has the highest electrical conductivity?
    a) Steel.
    b) Aluminium.
    c) Copper.
    d) Silver

17. A circuit contains two unequal resistors in parallel,
    a) voltage drops across both are same.
    b) currents in both are same.
    c) heat losses in both are same.
    d) voltage drops are according to their resistive value.

18. All the resistances in figure shown below are 1 Ω each. The value of current in Ampere through the battery is
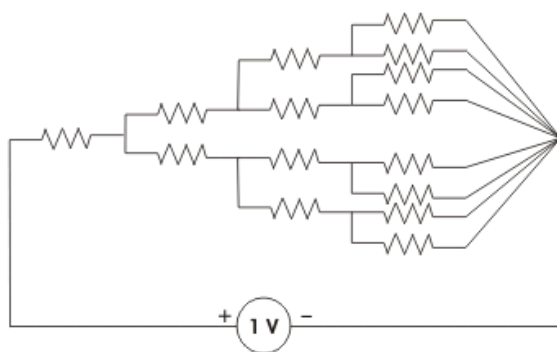
    a) 1 / 15
    b) 2 / 15
    c) 4 / 15
    d) 8 / 15

19. One horse power is equal to
    a) 102 Watts.
    b) 75 Watts.
    c) 550 Watts.
    d) 735 Watts.

20. The permanent magnets are made from which of following materials?
    a) Soft iron.
    b) Ferromagnetic.
    c) Paramagnetic.
    d) Diamagnetic.

21. Inside a hollow conducting sphere
    a) electric field is zero.
    b) electric field is a non zero constant.
    c) electric field changes with distance from the center of the sphere.
    d) electric field changes with the magnitude of the change given to the conductor.

22. In which of the transformer is the secondary nearly short-circuited under normal operating condition?
    a) PT.
    b) CT.
    c) Power transformer.
    d) Distribution transformer.

23. The strength of current in 1H inductor changes at rate of 1A/sec. Find the voltage across it?
    a) 2 V.
    b) 1 V.
    c) 0.5 V.
    d) None of these.

24. The electric field at a point situated at a distance d from straight charged conductor is
    a) proportional to d.
    b) inversely proportional to d.
    c) inversely proportional to d^2.
    d) none of above.

25. The incandescent bulbs rated respectively as P_1 and P_2 for operation at a specified main voltage are connected in series across the mains as shown in the figure. Then the total power supplied by the mains to the two bulbs is
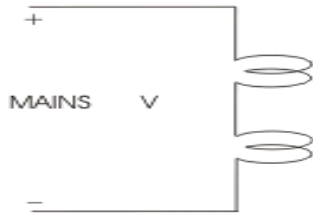
a) $P_1P_2 / (P_1 + P_2)$.

b) $\sqrt{(P_1 P_2 + P_1P_2)}$.

c) $P_1 + P_2$.

d) $\sqrt{(P_1 \times P_2)}$.

26. The speed of a 4-pole, 60 Hz synchronous machine will be
    a) 1800 rpm.
    b) 2400 rpm.
    c) 3000 rpm.
    d) 3600 rpm.

27. A DC motor is connected across the AC supply, it will
    a) run at normal speed.
    b) not run.
    c) run at lower speed.
    d) burn due to heat produced.

28. Which of the following has the installed capacity of 64 MW?
    a) Tala Hydropower Plant
    b) Chhukha Hydropower Plant
    c) Kurichhu Hydropower Plant
    d) Basochhu Hydropower Plants

29. Short circuit currents are due to
    a) single phase to ground faults.
    b) phase to phase faults.
    c) two phase to ground faults.
    d) any of these.

30. The rural households of Bhutan have electricity tariff of Nu. 0 per kWh for consumption:
    a) 0 - 80 kWh
    b) 0 – 100 kWh
    c) 0 – 120 kWh
    d) unlimited kWh

PART II – Short Answer Type Questions (20 Marks)

Answer ALL the questions. Each question carries 5 marks. Mark for each sub-question is indicated in the brackets.

1. Name five ways to conserve energy at your home. (5 marks)

2. Prove De Morgan's Theorem. Draw logic gates and table. (5 marks)

3. a. What is the main difference between run-off-the-river type hydropower and reservoir type hydropower? Provide one advantage and one disadvantage or each type? (3 marks)

   b. Provide one advantage and one disadvantage of HVDC transmission system (2 marks)

4. Aum Sonam Wangmo, a residential consumer of Gelephu has following connected load:
   - 10 compact fluorescent lamps (CFL) of 15 W each,
   - 5 incandescent lamps (bulbs) of 100W each,
   - 1 LCD TV of 40W,
   - 1 electric boiler of 1000W,
   - 1 rice cooker 1000W,
   - 1 refrigerator of 200W and
   - 1 electric room heater of 1500W.
   Her use of electricity during a day is as under:

11 pm to 6 am	3 CFL for outdoor and refrigerator
6 am to 7 am	electric boiler, TV and refrigerator
7 am to 8 am	rice cooker and refrigerator
8 am to 6 pm	refrigerator

6 pm to 7 pm	electric boiler, refrigerator and TV
7 pm to 8 pm	rice cooker, 5 CFLs, refrigerator and 3 bulbs
8 pm to 11 pm	TV, refrigerator and heater

Find

a) connected load (1 mark)

b) maximum demand (1 mark)

c) energy consumed in a day (1 mark)

d) monthly energy bill if the consumption is same everyday and the electricity tariff as under:

Block	kWh/month	Energy charge (Nu. /kWh)
I	0 – 100	1.28
II	101 – 300	2.45
III	Above 300	3.23

(1 Mark)

e) Name the electricity regulating body that approves electricity tariff of Bhutan. (1 mark)

SECTION B
Case Study

Choose either Case 1 or Case 2 from this Section. Each Case carries 50 marks. Mark for each sub-question is indicated in the brackets.

CASE 1

A Ferro Alloy industry located in Pasakha produces ferro-silicon alloys by melting raw materials at a very high temperature with the help of electric furnace. The mixture of the raw materials is subjected to this temperature with the help of heating element (three electrodes) in the furnace.

To improve the performance of the industry, your assignment is to conduct diagnosis of the transformers used in the industry. The electrical network of the industry has following connections:

- Three phase main transformer of 25MVA, 66kV/11kV.
- Two cables come out of the main transformer.
- One cable coming out of the main transformer after stepping down the voltage and goes to three electrodes in the furnace through three single-phase transformers of 7MVA each.
- Each electrode is of 3 MW load.

- The other cable out of the main transformer goes to10 different loads, which are motors, fans and pumps through an auxiliary three phase transformer of 2.5 MVA, 11kV/433V.

You are required to answer following:

i. Draw the electrical single line diagram for the above network. (5 marks)

ii. The main transformer 25MVA, 66/11kV has primary resistance of 2.78 Ω and the secondary resistance of 0.02 Ω. Its eddy current loss is 50 kW and hysteresis loss is 50 kW. Calculate the copper loss and core loss. (5 marks)

iii. The total load on the secondary side of the auxiliary transformer is 1 MW and the furnace is 9 MW (3 MW for each electrode). Calculate the total load on the main transformer and the percentage loading on the main transformer at 0.8 pf? (3 marks)

iv. Calculate the efficiency of the main transformer using copper loss as 502kW, core loss as 100 kW at full load and power input of 25MVA at 0.8 pf. for the following loadings:
   a) 50% loading (2 marks)
   b) 60% loading (2 marks)
   c) 80% loading (2 marks)
   d) At what ratio of Copper loss to Core loss does transformer attain maximum efficiency? Calculate the maximum efficiency. Calculate the % loading at this efficiency? (3 marks)

v. Explain why transformers are rated in kVA or MVA but not in kW or MW? (2 marks)

vi. Explain how core loss can be measured with an open circuit test with the help of diagram (4 marks)

vii. What is silica gel used for in transformers? (2 marks)

viii. If the owner chooses to install of the transformers in another plant located in Thimphu (higher altitude), what would be the effect on the transformer performance? (2 marks)

ix. Quite often due to the supply voltage, the voltage of the transformer is observed to be lower than its rated voltage. How can voltage be regulated in transformer? Explain. (2 marks)

x. When the plant is shut down during night hours, the power factor of the transformer is observed to be very low. Explain. (3 marks)

xi. The three phase auxiliary transformer is supplied by 11kV line from the main transformer. Calculate its secondary phase and line voltage for the following connections if the ratio of turns per phase is 25.4.
   a) Y – Y (2 marks)

b) Y - Δ (2 marks)

c) Δ - Y (2 marks)

d) Δ - Δ (2 marks)

xii. What will happen to the transformer if it is supplied with DC supply of same voltage? (2 marks)

xiii. What are the advantages of using one 3 phase transformer over three single phase transformers? (3 marks)

CASE 2

i. The ministry you work for has a newly constructed meeting hall of 16m x 10 m. It is to be illuminated with 30W Light Emitting Diodes (LED) lamps. CU of 0.68 and an MF of 0.75 are to be used. A minimum illumination of 260 lux is required at the work place. Use the mounting height as 2m. The manufacturer gives the lumen output of LED as 100 lumens per Watt. Assume space height ratio as 1.25.

a) Calculate the number of luminaries required. Draw the arrangement of lamps. (5 marks)

b) Estimate the size of cable. (2 marks)

c) Estimate the length and size of the cable required. (5 marks)

d) What size of the earth wire would you use? Why do we use earth wire? (2 marks)

e) There are two entrances to the hall at the two ends. Suppose your boss wants switches at both ends of the hall, how would you design the circuit? To demonstrate the design, draw the circuit with just one lamp and two switches. (3 marks)

f) Show the difference between radial circuit and ring circuit by drawing the diagram. Use 5 switches for the demonstration. (5 marks)

g) Name 5 tools you require to install lights and carry out wiring. (5 marks)

h) Recommend earthing for the meeting hall. Draw and explain. (5 marks)

i) Compare following lamps. (4 marks)
   Incandescent lamp, Light Emitting Diode and Compact Fluorescent Lamp.

ii. You are also required to illuminate the road of 300m long outside the hall by providing 50W street lamps of 900 candela. The width of the road is 4 m.

a) Calculate illumination directly under the street lamp. (2 marks)

b) Estimate the span between two poles and calculate the number of poles required if the scheme is to be estimated for obtaining minimum level of illumination of 0.6 lux. The span should be between 20 and 30m. (5 marks)

c) Draw the street light scheme (2 marks)

d) Estimate the total energy consumption in a month if the street lamps are switched on for 10 hours every day. (2 marks)

e) If an equivalent High Pressure Sodium Vapour lamps of 150 W were used in place of LED, how much would be additional energy would be consumed? What would be the energy cost if the electricity tariff is Nu. 3 per kWh? (3 marks)

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