1. Construct the duty cycle diagram and calculate the rms torque for a balanced mine winder with the following details:

- Time taken to load and unload the cages per cycle: 13 s
- Drum diameter: 4 m
- Shaft depth: 400 m
- Rope length between headsheaves and rope drum: 30 m
- Rope length between headsheaves and top position of cage: 25 m
- Mass of empty cage: 5 t
- Mass of loaded cage: 8.5 t
- Total equivalent inertia of winding drum and geared motor, including the rope wound on the drum, referred to the drum shaft: 130 t.m²
- Moment of inertia of each headgear sheave: 3.5 t.m²
- Diameter of sheaves: 3 m
- Maximum winding speed: 10 m/s
- Equal acceleration and retardation times of 11 s each
- Rope diameter: 37 mm
- Mass of rope: 5,823 kg/m

Answer the FIRST TWO questions and any FOUR other questions.
2. (a) Explain, with the aid of a vector diagram, the circumstances in which voltages greatly in excess of the supply voltage may occur in an overhead transmission line. (10)

(b) Give an account of the losses which occur in a transformer under load conditions and explain how they vary with load. (10)

(c) A 150 kVA single phase transformer has a core loss of 1.5 kW and a full-load copper loss of 2 kW.

Calculate the efficiency of the transformer

(i) at full load, 0.8 power factor lagging,

(ii) at 50% full load, unity power factor.

(iii) Also determine the secondary current at which the efficiency is a maximum if the secondary voltage is maintained at its rated value of 240 V. (20)

3. (a) Wet ore is fed into a mill at a rate of 140 t/h together with cyclone underflow pulp at 75 t/s. The wet ore contains 5 per cent moisture by mass. The density of the dry ore and cyclone underflow pulp is 2.7 and 1.817 t/m³ respectively.

Calculate the amount of water which should be added to the mill discharge sump (in t/s) to bring the relative density of the sump discharge to 1.225. (20)

(b) Sketch a flow diagram of a typical milling plant in a gold reduction works. Show the mill, thickener, cyclone, water reservoir and draw the water circuit in the diagram. (10)

4. (a) With regard to low pressure steam boilers, describe briefly:

(i) How you would test the safety valves
(ii) Where the sight glass blows down discharge to and why it is necessary
(iii) How often a boiler is blown down
(iv) How you would know that it is safe to open a boiler up for inspection
(v) Where the feed water line enters the boiler
(vi) What the cause of furnace explosions is and what precautions you would take to prevent them
(vii) How you would go about closing up a boiler and putting it back on line after an inspection. (20)
4. (b) A 50 mm diameter steam pipe, with an outside diameter of 60 mm is lagged to a diameter of 112 mm. The pipe is 50 m long and conveys wet steam at a pressure of 800 kPa.

Estimate the heat loss per hour if the ambient temperature is 20°C. The thermal conductivity of the lagging is 0.025 W·m⁻¹·K⁻¹ and the emissivity is 0.37 W·m⁻²·K⁻¹.

5. (a) Distinguish between three classes of fires and the type of fire extinguisher that should be used in each case.

(b) Underground fires are a major hazard in South African mines because of the large amount of timber that is used in the process of mining. Fire detectors are used extensively for early fire detection. Discuss two popular detection heads in use under the following headings:

(i) Principal of operation
(ii) Installation and maintenance
(iii) Power supply
(iv) Length of life.

6. An underground mono-rope system has a total length of 400 m between the tensioning pulley and the return pulley and is used to transport support-material to the working face of a mine. The bundles of wooden poles have a mass of 100 kg each and are transported to the top of a 1 in 5 incline, 310 m from the loading station. The bundles are conveyed at 20 m intervals and the rope velocity is 0.8 m/s. The rolling resistance coefficient is 0.15 and the coefficient of friction between the driving wheel and rope is 0.065. The driving rope passes two turns round the driving wheel.

(i) Calculate the tight side tension in the rope.

(ii) Calculate the minimum tension in the rope on the slack side to prevent the rope from slipping.

(iii) Calculate the minimum initial tension in the rope to prevent the rope from slipping on the driving wheel when fully loaded.

(iv) Calculate the power to drive the loaded rope.

(v) Select a suitable rope for the installation and state the resultant factor of safety.

(vi) Sketch a typical tensioning arrangement for a mono-rope installation.
1. (a) Briefly explain the basic principle of operation of dynamic braking as applied to a 3-phase slipping induction motor driving a mine winder.

(b) What are the advantages and disadvantages of dynamic braking compared to reverse current braking on an ac winding engine?

(c) With the aid of a braking torque-rotor current curve, explain what dangerous condition can occur while lowering a load by means of dynamic braking if some form of compensation or similar control is not used.

8. A plant requires a 10 MVA 550 V supply. The electricity supply company can provide a 6.6 kV supply with a maximum demand charge of R16/kVA and an energy tariff of 0.6 c/kWh or a 550 V supply with a maximum demand charge of R18/kVA and an energy tariff of 0.7 c/kWh. The additional equipment required to utilise the 6.6 kV supply costs R24/kVA and has an efficiency of 98%. The total operating charges are 20% per annum of the capital cost of the 6.6 kV equipment.

If the plant works at a constant full load and 52 weeks per year, determine the number of working hours per week above which it will be more economical to use the 6.6 kV supply.
(c) Write brief notes on each of the following occupational hazards giving methods by which they are detected and how humans are protected against the resultant disease:

(i) dust
(ii) fumes
(iii) gases
(iv) vapours
(v) smoke

(20)